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THE SCIENTIFIC MONTHLY

APRIL 1946

HOPES AND HURDLES IN THE CANCER PROBLEM

By E. V. COWDRY

DEPARTMENT OF ANATOMY, WASHINGTON UNIVERSITY

WHENCE comes this optimism that the problem of cancer can be solved? There is hope where a generation ago there was apathy bordering on despair. My friend Seelig reminds me of the notice "All ye who enter here leave hope behind" displayed by a wag over the door of Paul Ehrlich's laboratory when the master had the temerity to attack the cancer problem. And I can well remember being discouraged by my betters from work on cancer when I was a student. Now young men and women who come to the universities flushed with enthusiasm and ideals are not so regularly turned aside from work on cancer with the admonition "Don't waste your time." Instead they are encouraged to get the training and experience without which they cannot expect to make progress.

Today's optimism is not altogether because of the feeling that soon we may be able to put away the smoked glasses and the begging bowl and get along with the job, without having to spend half our time trying to raise the money to pay for experiments. This attractive possibility of getting research adequately financed stems from the fact that the public is becoming interested. A Gallup Poll released on July 21, 1945, shows that 81 percent of Americans favor a Congressional appropriation of $200,000,000 for the study and treatment of cancer and that 75 percent are willing to pay more taxes to provide the money. This poll was taken soon after the national campaign of the American Cancer Society. Let us hope that action will follow before the inevitable swing toward economy in expenditure of Federal funds sets in. The encouraging thing is that people are thinking in terms larger than before, though still microscopic compared with the human need to get rid of cancer, with its annual death rate of about 163,000 a year.

Some of the optimism may be attributed to the rather uncritical accounts of "wonder drugs" dished up for the public. These lead people to believe that medical science can leap over hurdles, which is true. But in cancer there are many hurdles, high and unique in character, as will be explained later. It would be unsafe to bank too much on the argument that because diphtheria, for instance, can be prevented, cancer can also be prevented by some simple means. The medical profession is *still* "from Missouri."

Probably the best way to trace this optimism to its real source is to talk with people who are actually investigating the problem in hospitals, research institutes, and universities; they are the ones who should know cancer best. A few are dejected, but many are somewhat excited by the results they are getting. They

feel that they are on the right track—sometimes after several false starts—and will talk enthusiastically of their experiments for hours. They cool off only (and promptly) when you switch the conversation from their work to yours. Without this consuming faith in what they are doing and refusal to spread their time and interest too thin, they would become useless. Also, they must use judgment in the interpretation of their results. Their habit of self-criticism is good. The difficulty is properly to limit this essential trait, for not infrequently they are also extra-critical of others, and, since diverse experiments have a place in the attack, their judgment is often based on inadequate knowledge of exactly what the other fellows actually are trying to do. Consequently, the visitor is apt to become confused by the mixture of justifiable and loose criticism, and this confusion is likely to increase the more cancer research laboratories he visits. The truth is that there are many right tracks, and that cancer can be attacked from more angles than any other major medical problem.

Why are there so many trails in the cancer problem that can be explored to advantage? One reason is that cancer can be studied not only in man but in a wide range of animals. All kinds of domestic animals—dogs, sheep, cats, goats, horses, and so on—suffer from cancer more or less frequently. Investigations of cancer in fish, frogs, chickens, and mice have been particularly illuminating. Animals of so many sorts are known to suffer from cancer that diligent search has been made for some species the individuals of which never have cancer. It was thought, rightly, that if some such cancer-free species could be found, comparison of it with another species abundantly afflicted with cancer might reveal the nature of the factors that determine resistance and susceptibility to this disease. Accordingly, zoological gardens have been ransacked for some cancer-free species, and animals collected in expeditions in foreign lands have been examined for cancer-free sorts, but without success. In no instance have negative results been obtained in a sufficient number of animals belonging to a single species to justify the conclusion that the species is free from cancer. So much for the vertebrates.

In invertebrates, also, cancer does occur, but its range of distribution is still more obscure. Even in plants a disease rather remotely resembling cancer has been discovered and therefore botany is well represented on the Committee of the National Research Council, financed by the American Cancer Society. Cancer is, then, the antithesis of mental disease. The psychiatrist can operate only at the human level where thoughts can be conveyed by speech. The cancer investigator can operate at numerous levels, perhaps at all the principal levels in the animal scale.

Other pioneer workers tried to find a parallel contrast in man, that is, between a cancer-free race or tribe and a cancer-rich one, again to get at the resistance and susceptibility factors. The first reports that cancer is absent in the Eskimos and others were invariably followed by the discovery of cancer when more individuals were examined. It is also clear that cancer in man is not a modern disease, but has been with us from prehistoric times.

A second reason why cancer supplies such abundant openings for research is found in the fact that, unlike most other diseases, it is not limited to a particular age group. It can develop from before birth to extreme old age. Though the peak of greatest number of deaths from cancer in men is from 60–69, and in women from 50–59, there were in 1942 more deaths from cancer in children under five years of age than from infan-

tile paralysis, or from acute nephritis, or from all diseases of the ear and mastoid lumped together. And in the same year deaths from cancer in the age groups 5–9 and 10–14 exceeded those from dysentery, whooping cough, diphtheria, or measles, which goes to show that, while cancer is not common in infants and children, it is deadly.

Third, cancer can develop in more parts of the body than most other diseases, so that the tissues and the ages at which it can be studied are varied. It is, of course, a disease of cells. For some unknown reason the cells are so modified that they become malignant, in the sense that they multiply without the usual bodily restraints, invade the territory belonging to other cells, and continue to monopolize everything until the patient dies, often extremely emaciated. A committee appointed by Surgeon General Parran has made the pronouncement that "malignancy is a universal cell potentiality, in that any cell has inherent in its make-up the potentialities for unlimited and uncontrolled growth." This may be too sweeping a generalization, but the fact of interest here is that the cancer investigator can profitably study the origin of cancer in cells of many sorts, each one of which poses a problem in itself which demands a concentration of techniques, physical and biochemical, physiological and pharmacological, pathologic and genetic. Multiplying the number of kinds of cells by the number of experts who should study each, one obtains a large figure.

A further consequence of the fact that cancer can present itself for study in any part of the body is difficulty in the establishment of departments of cancer in our medical schools. If created, such departments could not be self-contained units like those of gynecology, ophthalmology, urology, and the other specialties. They could only be superdepartments, that is, cancer hospitals, or else weak organizations treating and studying patients on suffrage in other departments throughout the school: cancer of the breast in the department of surgery, cancer of the uterus in the department of gynecology, cancer of the prostate in the department of urology, and so on.

A fourth feature of cancer which sets it apart from other diseases is the far greater number of agents that can produce it. The simplicity of syphilis (caused by a single type of spiral organism) or of tuberculosis (caused by a single kind of bacterium) is wholly lacking in cancer. The cancer-producing agents are called carcinogens, because under certain conditions they can generate cancer. They are of two kinds: external and internal.

Sunlight is the most universal of external carcinogens, but its power to produce cancer is relatively feeble. Long exposure through many years is ordinarily required. Cancer of the lip, caused by shorter, but more intense, exposure to sunlight, is one of the prices paid by some of our Pacific veterans. Dust, especially in particular kinds of mines, X-rays, radium and radioactive substances, many coal-tar products, particularly tars and certain aniline dyes, and numerous other chemical substances can produce cancer if conditions are favorable. And cancer tends in a small minority of cases to follow burns and mechanical injuries, such as blows on the bones, breasts, and testicles.

The carcinogens that strike from within are more difficult to identify. The male, and more definitely the female, sex hormones are under suspicion as possibly belonging in this category; but, again, one has to stress the word "potential" for they usually do not cause cancer. Without the use of these and other steroid compounds, evolution, as we know it, could not have taken place.

Still another property of cancer con-

tributes to our perplexity. Sometimes it is easy to fix the date of last exposure to a carcinogen and to measure the time elapsing before cancer appears. A worker, after a varying length of service in a dye factory, may change his occupation and never again be subjected to the same cancer hazard. Statistics show that he may develop cancer of the uninary bladder one to seventeen years later. After the last repeated exposure to X-rays, the physician or X-ray technician may get cancer of the skin in one to eleven years. After an acute burn, cancer may develop at the spot in from one month to two years. Evidently there are long paths and short cuts to cancer. The concatenations of circumstances are almost impossible to unravel.

But perhaps the feature of cancer most difficult of analysis is susceptibility. The degree of susceptibility to an infectious disease such as infantile paralysis usually depends on the concentration of specific material antagonistic to the virus in the blood stream. In cancer many types of cells are susceptible and *appear* to have individually different degrees of susceptibility. We say "appear" advisedly, because one encounters at every turn in the cancer problem wheels within wheels, and we cannot tell how much the frequency and speed of cancer development depend on the cells that undergo the transformation and on the activities of other cells and body fluids. The body is a glorious mixture, never the same at different intervals of time, but always changing. The fact that among cells of one and the same type cancer development is subject to variation immensely complicates the problem, but it does hold out a tantalizing element of hope.

Consider first the matter of inheritance. Some families show a cancer-frequency distinctly greater than that observed in the rest of the population. Failing evidence in these families of unusually great exposure to carcinogens, the assumption is that some of their cells are more susceptible to cancer than are cells of the same sorts in families in which there is but little cancer. This is a kind of organ susceptibility. Thus, as many as ten of a family of sixteen children have had retinal cancer, and cancer of the breast and of some other organs have a tendency to run in families. In identical twins cancers usually appear simultaneously and symmetrically, and are similar in kind of growth. Thus, where the hereditary endowment is the same (identical twins), the cellular susceptibility to cancer development is generally the same, and where it is different, as in different families, the cellular susceptibility is also different.

Even within a single individual during his lifetime, the susceptibility of some cells to agents causing cancer is subject to change, as in *Xeroderma pigmentosum,* a childhood disease in which the skin becomes dry (*Xeros*) and pigmented, and the susceptibility of its epidermal cells to the carcinogenic influence of sunlight increases progressively. If a person has a cancer the chances are greater that he will acquire another cancer somewhere else in his body than are those that a normal person will develop a cancer. In other words, the presence of one cancer seems to facilitate the development of other primary cancers in the same individual. Why we cannot tell, but perhaps the first cancer increases the susceptibility of other cells to carcinogens. The qualification "perhaps" must be retained until evidence is forthcoming of equal exposure to carcinogens in cases of single and multiple cancer and of equal susceptibility to begin with.

In lesions styled "precancerous" a somewhat better case can be presented for increase in susceptibility. White-looking surface lesions in the mouth and on the tongue, existent for years, may flare up as cancers. Harmless-looking

moles of long standing may suddenly change, blacken, and give rise to virulent cancers. In deeper parts of the body other precancerous lesions may persist for years without symptoms and suddenly become malignant. But not all of the white plaques, moles, or other so-called precancerous lesions do this, only a minority of each kind. Again we do not know why. The point is that the frequency of the malignant transformation is greater in their cells than in other cells of the same types. This suggests, but does not prove, an increased susceptibility among some of the cells of precancerous lesions.

Since instances of acquired hypersensitiveness (or allergy) are found to be caused by a host of different substances, it seems not unlikely that some of the motley crew of carcinogens, and also some agents which are not cancer-producing, can alter cells in the direction of increased susceptibility. In the long years up to the age when most cancers are noticed they have abundant opportunities to work. It is conceivable that we are concerned also with a decrease in susceptibility to carcinogens. In mice of certain strains the susceptibility of epidermal cells to carcinogen is less in old than in young animals.

It is unnecessary to sketch further the broad scope and intricacy of the cancer problem—the many kinds and ages of animals involved, the many cell types, the host of different cancer-provoking agents, the great variation in time required to produce cancer, and the cellular susceptibility subject to change. No wonder that cancer research is so diversified and that some investigators are of the opinion that before we can get really started more must be learned about normal cellular physiology and growth. Indeed, almost any line of investigation dealing even remotely with cells is helpful, for cancer is unquestionably a cellular problem. But it is desirable to arrange the established facts in such a way that they are a little less overwhelming and so that research can be aimed more accurately at a solution.

A MEASURE of orientation is given by comparing the events leading to muscular contraction with those which result in cancer production. Muscular contraction and cancer production are of course very different phenomena. We are concerned only with the series of steps leading up to them, not at all with the nature of the steps.

First, a few words about muscular contraction. This can result from stimuli of many kinds: light, sound, heat, cold, taste, smell, touch, pressure, and so on. The stimuli activate receptor cells particularly susceptible to them. These receptor cells generate nervous impulses which are transmitted in their long processes, or in nerve cells strung out in series, by many sensory pathways into the central nervous system, where they are correlated and adjusted. From the central nervous system the impulses are carried by motor nerve fibers to a muscle. These motor fibers have been aptly called the *final common path* by the great physiologist Sherrington. They are the *final* nervous elements in the sequence, that is, those which reach directly to the muscle. They constitute a *common path* into which the impulses, initiated by many sorts of receptors, traveling to the central nervous system by diverse sensory nerves, converge and funnel into the muscle. For example, a muscle in the hand on the steering wheel of a motor car can contract in response to something seen, or heard, or felt in the motion of the wheel, or in consequence of some past sensation or experience stored in memory. Yet the impulses, whatever their source, reach the muscle through the same motor nerve fibers acting as their final common path.

In the comparison it is convenient to

consider activating agents, sequence of events, modifiability, and final common path:

(1) *Activating agents.*

In muscular contraction the stimuli are of wide variety. When carefully considered it is found that they are so different that it is not possible to name a property which all of them possess in common, other than the capacity to produce a change. If they act with sufficient strength they initiate a sequence of events, in the actual performance of which they do not participate.

In cancer production the carcinogens are also of many sorts, in which it is similarly not possible to discover a common property. If they act in sufficient strength, or repeatedly over a long enough time, they start chemical changes, in the continuation of which they apparently do not participate.

(2) *Sequence of events.*

Those leading to muscular contraction may be long or short, depending upon the number and the character of the cells in series. Between each cell resistance is greater than in its substance. There is a kind of build-up of force to overcome this resistance, and time is lost.

The events culminating in cancer production are, by comparison, as yet largely hypothetical. But it seems logical to assume the existence of such steps in series differing *inter se* both in number and character, and also to imagine a kind of build-up to overcome inertia between them.

Obviously, to unravel the sequences leading into the final common path of cancer production is much more difficult than to identify those reaching into the final common path of muscular contraction. The structural elements in the neural sequences are definitely arranged in space and stay put, so that they can be seen microscopically and their activities measured quantitatively. The events in carcinogenesis are centered in the same area of tissue (with unknown spread elsewhere), and later events obliterate those going before. Moreover, as already related, cancer can develop in many different sites, the differential characteristics of which may be not without influence on the course of events. These differential characteristics are as numerous as are the kinds of tissues. One immediately thinks of high vascularity, low vascularity, and avascularity, presence or absence of lymphatic drainage, and degree of cellularity. Moreover, the steps up to cancer production take in the tissue fluids, whereas those reaching into the neural final common path are for the most part insulated from them by impermeable myelin sheaths and dense cellular and fibrous investments.

Because of the partial insulation of neural components, events once started are perhaps more likely effectively to reach into the final common path and bring about muscular contraction than the events in carcinogenesis are to cause cancer. In other words, there are fewer opportunities for them to fade out than in cancer production, the operating time for which is also so much longer, and in which so many carcinogens so seldom initiate sequences reaching the goal.

(3) *Modifiability.*

A short cut is possible by elimination of some of the events that ordinarily lead to muscular contraction, as when contraction results from direct electrical stimulation of muscle. Earle has been able to bring about the malignant change simply by the addition of carcinogen to susceptible cells.

The series of events resulting in muscular contraction can be reinforced by the operation of additional activating agents, or stimuli, and by voluntary effort. So, also, the steps eventuating

in cancer production can be made more effective and the time shortened by additional carcinogens stepping into the sequence initiated by the primarily acting ones.

In states of hyperexcitability of the receptors of nervous elements, and perhaps of muscle, ordinarily inadequate stimuli can produce contraction. In conditions of decreased excitability and of block somewhere in the sequence, even strong stimuli can fail to result in contraction. By conscious inhibition the hand can be held against a hot iron, the impulse to remove it being overruled.

Susceptible cells live in a world of potential carcinogens. These ordinarily fail to produce cancer except when the force exercised is sufficient. Some instances of hypersusceptibility on the part of such susceptible cells are known. Cancer production can be speeded up, as when estradiol benzoate is administered to susceptible animals in addition to the carcinogen. And it can be slowed down. Decrease in susceptibility and complete block of cancer production remain more of a mystery than like phenomena in muscular contraction.

(4) *Final common path.*

Muscular contraction at the ends of motor nerves is the same in muscles of a given sort, irrespective of the kind of initial stimulus. Among vertebrates the nerve fibers in the final common paths deliver the same kick to muscle by liberating somehow a definite substance, acetyl choline. The quality of the contraction depends on the type of muscle, whether smooth, skeletal, or cardiac, and perhaps on individual differences within types.

Cancer production in cells of a given type is similar, irrespective of the kind of carcinogen acting on them. Thus, a squamous cell cancer can result from carcinogens as different as solar radiation, radium, and many chemical substances. Moreover, individual cancers of a definite type show striking degrees of resemblance, even though present in animals of different species—indeed, of different classes—of vertebrates. The assumption is not farfetched that the final kick delivered to susceptible cells is one and the same in all cases of cancer production. The quality of the resulting cancer is primarily conditioned by the type of cell thus influenced. Since, as previously noted, a vast array of different types of cells possess malignant potentiality, the different sorts of cancer are legion.

This view of events not only illustrates the difficulties ahead but also indicates where the problem of cancer can be attacked with some hope of success.

Preventive measures of avoidance cannot be expected ever to banish cancer, as is being done in many districts in the case of malaria, for example. It will be helpful to keep up the search for hitherto unrecognized carcinogens and to try to limit exposure to those already known to the point where they are harmless as cancer-producers. To avoid them all, or to reduce them to impotence as cancer-producers, and still to go on living would be about as feasible as to close the doors of our bodies to sensory stimuli from without and from within and to continue alive. Yet, when there is reason to suspect the existence of unusually great susceptibility to cancer, efforts at avoidance of the activating agents must be redoubled. And it is not beyond the realm of possibility that means will eventually be discovered to decrease this susceptibility.

To block the sequences of events initiated by these activating agents before they funnel into the final common path is of course a possibility. The difficulty is that in man we so often do not know that anything untoward is taking place until the cancer appears. The so-called precancerous lesions may or may not be

representative of events leading to cancer. We need to learn more about them. The warning signal of pain, so helpful in promoting survival in other conditions, is usually withheld until some time after the malignant change takes place.

If we could discover what happens at the end of our hypothetical final common path we might be able to prevent the cancerous transformation. The way to get at it seems to be to unearth the fundamental difference—or differences—that exists between normal and cancerous cells of the same type on which the difference in behavior depends. Armed with knowledge of the nature of the difference, we would be better able to ascertain how the change is brought about, or, coming back to our comparison, what is the kick delivered to susceptible cells at the end of the final common path. If it is some kind of chemical substance, or perhaps even a virus, it is conceivable that it might be possible in some way to inactivate it, or to alter the cell membranes so as to protect the cells against it. But people are dying of cancer every day. Therefore, while striving for data on this fundamental difference, in order to make the proper start, unremitting efforts should continue, even blindly, trying to save the cells from the unknown influence. Curare, which prevents muscular contraction by acting where the fibers of the neural final common path impinge on muscle, was a chance discovery by South American Indians.

Coming now to the cells which have in some way become cancerous, obviously it is important to devise some test of blood or urine which will reveal the presence of cancer wherever located in the body. If cancer cells give off some substance not produced in their absence, this might be demonstrated by some test. But the test would have to be extraordinarily delicate, because beginning cancers consist of only a few cells, incapable of releasing much of anything. There is also the possibility that something detectable is released by noncancerous cells, in consequence of the presence of cancerous ones, which likewise is foreign to a body free from cancer. Again the test would have to be very sensitive. If, on the other hand, such specific substances are not formed and we have to do only with the production of more or less of substances present also in the absence of cancer, the chances are obviously not so favorable. Cancers of sufficient size to produce a noticeable increase or decrease might be as readily detected by present methods.

Lastly, and of supreme importance, are efforts to deal with cancer cells which have been identified. The malignant property appears to be permanently engraved on them. If it is in the nature of a mutation, the likelihood is remote of making these cancer cells revert to the status of their forebears, who were useful members of the cellullar community. Yet this must be attempted. Merely to deprive the cells of their malignancy and viciousness with the idea of withdrawing their teeth, so to speak, may turn out to be more feasible, and must be attempted. However, the main line of attack in cancer evidently is to discover the specific vulnerability of cancer cells so that they can be killed off without at the same time destroying normal cells.

There can be no question but that the approach to the central objective is to find out how the manner of life of cancer cells differs from that of normal cells. The National Cancer Institute and the American Cancer Society, the two organizations from which we naturally expect most, are digging into this problem of cellular physiology. Yet the need for relief from the cancer plague is so urgent that, while diligently providing this groundwork, a frontal attack on the cancer cells, armed only with

present knowledge, should not be postponed. This direct offensive should be on cancer cells of a single type in animals on which experimentation is practically unlimited, and it should be supplemented by cautious follow-up experiments on the same sort of cancer cells in humans.

Organization should be on a large scale so as to bring to bear on the malignant cells all the influences which affect cellular activity and do not kill the animals. But this should not be done altogether blindly. The selection of influences to be tested should be based on the carefully considered advice of expert physiologists, endocrinologists, pharmacologists, biochemists, physicists, radiologists, microbiologists introducing new "wonder drugs," and physicians. Particularly should many products hitherto on the secret list in connection with the war be tried. The experiments should not be limited to possible means of altering the conditions of cell life by the injection of substances, by alterations in diet, by subjection to physical agents, but should include surgical intervention by removal of organs or parts of organs which might be expected profoundly to modify these conditions. The spirit of inquiry should be that of trying everything, not omitting even the unlikely influences, such as animated Kettering in the search for a substance that would take the knock out of gasoline, and Edison in the invention of a filament that gave electric light to the world. The driving force of *must*, which has achieved the seemingly impossible in war invention and industry, should prevail. Whatever organization meets this challenge should be ready to work day and night in several shifts to stem the appalling death rate from cancer.

This goal is attainable. In practice, remarkable and significant variations are observed in the behavior of cancers. Some primary cancers produce whole flocks of secondary growths in other parts of the body, others do not. A large primary tumor may produce small secondary growths, whereas a small primary tumor may give rise to huge secondary tumors. Some grow at an amazing speed and others slowly. A single cancer may enlarge rapidly, then enter into a period of slow extension, almost of latency. Another may grow slowly, and then speed up. In extremely rare cases an active cancer may completely disappear, as in the well-authenticated case of Sister Gertrude. Wholly unknown forces are sometimes at work in the body which accelerate, retard, and even abort cancers. Perhaps it was a realization of the operation of such influences which led Ehrlich to attack the cancer problem despite the warning "All ye who enter here leave hope behind."

HUMANISM—A RELIGION FOR SCIENTISTS

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OPPOSITION of science and religion seems sensible to some and absurd to others; which view one holds depends in part upon what one means by religion. If religion is defined as consisting of traditional dogmas and the ecclesiastical systems interested in maintaining them, then the view that science and religion are opposed may well be justified. But if religion be conceived as faith in the worth-whileness of living and active pursuit of what seems worth while, then science and religion are not opposed and science is a very important part of religion.

Narrow religionists and narrow scientists alike agree that each is opposed to the other, but broad religionists and broad scientists recognize that science and religion involve each other. It is said that science deals with facts and religion with values. This is true, but it is not the whole truth. For there are facts about values and vice versa.

As for facts about values, it is a fact that values exist; that they are what they are; and that they are experienceable. Values, as observable data, are open to scientific investigation, and it is a sad commentary on science that such investigation has been so long neglected by so many of those who have faith in science.

As for values about facts, if facts were of no value, scientists would not be interested in them, and if they were not useful, no one would ever become a scientist. Even those "pure" scientists who seek "facts for their own sake" seek values, because for their own sake means that the values are self-contained. Thus science is pursuit of values as well as of facts.

If religion is the comprehensive name for pursuit of values, then science, insofar as it is pursuit of values, is a part of religion. This conclusion is so unsatisfactory to those scientists who are in the habit of thinking of religion in terms of traditional dogmas that some explanation of the "true" nature of religion seems desirable, that is, of that view of the nature of religion which one would reach if he investigated the matter scientifically. In other words, the investigator should be open-minded, tolerant, willing to be guided by experience and reason, and without prejudgment as to what the conclusion will be. Some scientists who maintain such an attitude toward problems within their field fail to do so in other fields, and the difficulty they have in maintaining a scientific attitude in the field of religion, or with respect to values, is so great that they have come to insist that science cannot deal with values and, by implication, with facts about values. But other scientists have faith in the applicability of scientific attitudes to facts about values and have sought to make a scientific approach to religion.

The scientific investigator will make extended and careful observation of data, classify data into types based on similarities and differences, formulate hypotheses about the nature of the data, and verify hypotheses by applying them to additional data. In seeking to understand religion the scientist observes extensively whatever is called religion by different people at different times; he examines hypotheses which others have held as well as those suggested by his own surveys; and he tests all these hypotheses to discover their relative merits in inter-

preting the data. Hypotheses which fail to fit all of the facts remain unacceptable, except that, in the absence of any completely satisfactory theory, that hypothesis which is most adequate is held tentatively as the most satisfactory. In formulating a scientific definition of religion, scientists would seek all those characteristics that together are both necessary and sufficient for the existence of what people call religion.

One such tentative hypothesis is presented here. This hypothesis, briefly stated, is that religion involves five essential characteristics: values, beliefs, desires, faith, and action. A word about each is needed.

Religion involves values (and disvalues) in two senses: felt values and valued objects. Felt values, or feelings and emotions, are of many sorts: love and hate, hope and despair, awe and contempt, security and danger, peace and turmoil, pride and mortification, satisfaction and frustration. "Objectified values" are of many sorts. Since feelings of value and disvalue are naturally "projected into objects," we seem to see what we feel as apart from us. We not only have feelings of love, but we seem to love others because they are lovable; we not only have feelings of hate, but we seem to hate others because they are hateful. We objectify our feelings of good and evil as due to gods and devils.

Religion involves beliefs, or theories believed, of many sorts. These may be summarized as theories about the nature of the universe, about the nature of man, and about the nature of values. The sum total of one's beliefs constitutes his philosophy of life.

Beliefs about the nature of the universe normally include theories of the origin of the universe, its structure or composition, the kinds of changes, processes, and developments taking place in it, and its end, or future prospects. Since men are profoundly interested in values, they are concerned especially about the fate of values and about whether or not the universe is friendly to values. Theories about the nature of the universe are sometimes called "cosmologies," and often include "theologies." Especially today, they rest upon the results of the various sciences. Part of the reason for the alleged antagonism between science and religion is that many religionists insist upon the truth of centuries-old and now-obsolete science. Religion depends on science; or, science is a part of religion. Cultural lag in our ecclesiastical systems has caused conflicts. These conflicts are not essentially between science and religion, but between religion based on modern science and religion based on ancient science.

Beliefs about the nature of man normally include theories identical with those about the nature of the universe. What is man? Is he an eternal or a temporary being? If both men and the world change, can men hope for conservation of their values in the future? Is human nature such that values can be finally and completely achieved, or such that perfection can be hoped for but never achieved? Is human nature inherently good, or evil? Or both? Or neither?

Beliefs about the nature of values normally include theories of the origin of good and evil, the kinds of values and disvalues, the achievability, conservability, creatability of values and disvalues, and the fate or future prospects of values and disvalues. Where did good and evil come from? What caused them? Did they always exist? Did they have personal or impersonal causes? Can they still be created anew? Of what do good and evil consist? Are they different kinds of things, or different aspects of the same kinds of things? Are there great and small values, temporary and eternal values? Since values

are related to desires, perhaps there are as many different kinds of values as there are of desires. These have varied from person to person, culture to culture, and time to time. All, however, have included desires for security (of life, food, children, health, home, etc.), desires for esteem, desires for love and friendship, and desires for more interesting activity. Beginning students of religions seem lost in a maze of unrelated value-beliefs. But persistent students discover common patterns of value-beliefs running through all religions.

Can the "good life" be achieved by all men? What must one do to get what is good and to avoid what is evil? What kinds of conduct or behavior are best to achieve goodness? What kinds of ideas or attitudes should one have? What kinds of instruments should one use? What kinds of beings should one seek to serve or seek to destroy? Are values given to us or made by us? Are values to be waited for or sought after?

Can values, once achieved, be preserved? Is the good life transient or eternal? Does a good deed now deserve an eternal reward, or is each good deed its own reward? Is evil temporary or permanent? Will all values cease some day, or will they endure forever? Will our values always be the same, or will they change and evolve into different values? What guarantees are there about the future of values?

Religion involves desire to achieve values and to avoid disvalues. Not just indifferent belief, but actual desire to achieve values is essential to religion. One must want what is good. It is natural to want what is good, and thus, to this extent at least, it is natural to be religious. Desire to avoid evil, not just helpless acceptance of ills, is also essential to religion. One must want to destroy or diminish evil, and insofar as it is natural to want to do this, men are naturally religious. Since religion seeks abatement of what is bad, the religious naturally desire to abide by justified taboos.

Religion involves faith in the truthfulness or usefulness of one's beliefs and in the realizability of one's desires. Having beliefs is not enough; in order to be religious, one must trust his theories in actual practice. "Faith," someone has said, "is knowledge upon which one is willing to risk himself in action." Having desires is not enough; in order to be religious, one must have faith that his desires for the good life can be fulfilled. He must have faith that "the universe is friendly to values," at least in some measure.

Religion involves action. "Faith without works is dead." Religion involves acting upon one's faith in one's beliefs and desires. Religion is a quest, or a quest*ing*, for the good life. Religion is devotion to values, not so much devoutness of attitude as devoting serious effort to active pursuit of values. Religion is more than an experience of values, more than a philosophy (or science) of life, more than a set of sincere desires, and more than a faith that everything will turn out all right in the end. It involves active practice of one's faith in one's philosophy of values.

So much for a tentative definition of the nature of religion. Critics will contend that it is too general. The reply will be—and this is one of the important points of this article—that most definitions of religion are too narrow. Theology is a possible, but not an essential, ingredient in religion; there are atheistic religions. Those who insist upon theological ingredients do so partly because there is a preponderance among them of those who prefer to base their beliefs upon ancient rather than on modern science. As more investigators without vested interests, financial or educational, in traditional systems study the nature of religion, the less often do theological

items appear among what are considered the essentials of religion.

If this theory of religion is adequate, it will apply to everything that is commonly called religion and to some things that are not. Supernaturalism, naturalism, occultism, communism, animism and atheism may all be varieties of religion. Fetishes, family Bibles, music, marriage, politics, prayer, orgiastic dances, statistical analyses, scientific inquiries and heretical inquisitions; virginity mores, fertility practices, artificial insemination, capital punishment, church attendance, bombing raids, building of libraries and burning of books—all are possible parts of religions. But they are not all—or, rather, not at all—essential to religion. Each scientist can review the foregoing summary of essentials to see whether or not he himself participates in all of the essentials listed. If he does, and if this theory of religion is adequate, then he may properly be called religious, regardless of whether he appreciates or depreciates local religious traditions.

IF SCIENCE is a part of religion, then which religion seems best suited to the interests of modern scientists? Many religious traditions have become modified and have adapted themselves to newer scientific discoveries, and many will no doubt continue to do so. But none is better suited to scientists than a movement called "Religious Humanism" or, simply, "Humanism." Humanism is not the only religion for scientists, for all religions involve some science, and scientists are as much entitled as others to pursue their preferences in matters of values. But Humanism is a religion erected upon the results of modern science, and thus tends to be the religion best suited to the interests of scientists. Humanists do not necessarily shun all traditional ideals, but neither do they find traditional beliefs at all essential to their ways of thinking. What, then, is Humanism?

Humanism is science plus values. Or, if you prefer, values plus science. Humanism is a religion of those who tend—and intend—to accept the conclusions of scientific investigation as their "beliefs" and who have "faith" that their "desires" for a better life will be justified by their "acting" upon their faith in such beliefs. Whoever does this is already a Humanist, whether he knows it or not. Such an answer seems so simple that many will want to inquire about further details. Since the question of the existence and nature of God has loomed so large in many recent religious views, many scientists will want to ask: What about God? The Humanist will reply: What does the scientist say about God? Ancient scientists assumed his existence as a major premise. But centuries of critical analysis have led scientists to less and less certainty about his existence and nature. Modern scientists not only do not place assumptions about the existence and nature of God among their major premises, many of them do not consciously involve him, or it, among their assumptions at all. Humanism is affected by this increasing uncertainty; in fact, Humanism is a product of it. Humanism is a religion in which belief in the existence of God is not essential.

Does this mean that Humanism is atheistic? No. If scientists could prove that there is no God, then, no doubt, atheism would become an essential of Humanism. So long as this seems unlikely, Humanism is a religion in which belief in the nonexistence of God is not necessary. Some Humanists are theists and some are atheists, but, insofar as they are Humanists, they hold some beliefs in common that are more important to them than either their theistic or atheistic beliefs.

Humanism is characterized by an em-

phasis upon the ideal of the brotherhood of man and by a neglect of the ideal of the fatherhood of God. Some Humanists are, and some are not, interested in the doctrine of the fatherhood of God, but all are agreed that the ideal of the brotherhood of man is more important than the ideal of the fatherhood of God, and they are committed to faith in the practical necessity and desirability of the ideal of human brotherhood.

While some Humanists may feel that the ideal of man's brotherhood is fostered and somewhat sustained by the ideal of fatherly origin, most will agree that the brotherly ideal does not necessarily presuppose the fatherly ideal. Those Humanists who hold opposite beliefs with regard to theism naturally entertain some doubts about the wisdom of their opponents, but these doubts remain subordinate to their agreement about the superior importance of the ideal of brotherhood. Atheists who consider denial of the existence of God as more important than affirmation of the value of the ideal of brotherhood are very questionable Humanists, to say the least. Atheism is not only not essential to Humanism, but the more an atheist emphasizes his atheism, as compared to his faith in and practice of fraternalism, the less of a Humanist he is. Likewise, the more a theist insists upon his theism, the less of a Humanist he is. Thus, being a Humanist is a matter of degree.

The basis of the ideal of brotherhood, for Humanists, comes not from the Bible but from biology. Humanists accept the conclusions of biological scientists about the origin and development of man. The biological doctrine of struggle for existence and survival of the fit is buttressed by contributions from all the natural and social scientists, especially by those from social psychologists, political scientists, and historians. The story of human struggle for survival is not a pleasant one, and man's chances for survival seem to be better in a cooperative than in a competitive society. History's lesson, "United we stand, divided we fall," is hard to learn. Humanists have learned it. The belief that men are brothers, to be tolerated, if not loved, has become a practical necessity. The belief has a biological basis, but it is born and reborn as a consequence of the bitter experiences of unbrotherly conduct. Humanists are not particularly sentimental about brotherhood, though they are not unwilling to use sentiments about brotherhood in the interest of human survival and improvement.

Absence of traditional emphasis upon God as responsible for man results in emphasis upon man as responsible for self-control. The fate of humanity rests primarily in human hands, if in any hands at all. Faith in the possibility of some survival and improvement of human values is accompanied by faith in the willingness of human beings to accept full responsibility for actively promoting such survival and improvement. Acceptance of complete determinism does not prevent faith in the effectiveness of such freedom as is involved in self-determinism. Humanists hope that mankind will become increasingly self-determined through becoming increasingly self-determining. The pursuit of values, which constitutes religion, is facilitated by faith that willingness to assume responsibility for self-improvement will increase self-improvement. Humanists are interested in instilling in individuals desires for self-improvement and faith that science provides the best ways toward such self-improvement. Thus Humanism is a scientific religion—a religion for scientists.

Some religions are evangelistic. How about Humanism? Humanists differ. Among those who are not evangelistic, an attitude prevails that increasing Humanization, or "secularization," is taking place, and will continue to take

place, spontaneously, without any special, organized effort on the part of Humanists. Traditional religious systems are declining, judging by membership and financial statistics, and it is better to let them die a slow death than to oppose them openly, thus providing them with the kind of revitalization that thrives on opposition. Humanism progresses better, these Humanists hold, if industrial, governmental, educational, and social advancements are promoted without any suggestion that they are religious in nature. It is best served by "letting nature take its course."

Other Humanists are definitely evangelistic. One group, which organized what is now the American Humanist Association, issued in 1933 "A Humanist Manifesto," setting forth fifteen points of doctrine and calling for concerted action. This Association publishes the *Humanist,* edited by Edwin H. Wilson, at 1201 Union St., Schenectady, N. Y., and sponsors annually a "Conference on the Scientific Spirit and the Democratic Faith" in New York City. Another group, the Humanist Society of Friends, publishes the *Humanist Friend,* edited by Lowell H. Coate, at 2405 West 23rd St., Los Angeles, Cal., and includes more than forty ministers in its official list. A *Humanist Monographs* series is published by Hugh Robert Orr, director of the Humanist Society of San Francisco. Books and pamphlets are published also by the Canadian Humanist Group, with Blodwen Davies, Thornhill, Ontario, as secretary. All these groups advocate vigorous promotion of Humanism as an organized religion.

Between those who prefer to let nature take its course and those who seek to organize Humanism as an evangelical religion are many who are evangelical about promoting Humanistic values but quite indifferent to Humanism as an organized religion. Each scientist who, through research or teaching, wants, in addition to drawing his pay, to promote human welfare may be a Humanist of this kind. Each scientist who believes that his specialty contributes to human progress rather than service to God is a Humanist. And to the extent that he seeks to help others to have faith that the beliefs involved in his specialty will help them, he is evangelistic with respect to human values. Organizations of scientists for purposes of improving science, and thereby improving humanity, are Humanistic organizations. The American Association for the Advancement of Science is an excellent Humanistic organization, if one is to judge by its name, by editorials appearing in its *Bulletin,* by many of the articles appearing in THE SCIENTIFIC MONTHLY, and by published descriptions of its "saints," or honored dead, medalists, and prize winners. Recent *Bulletin* editorials urging scientists to accept more responsibility for guiding postwar reconstruction illustrate evangelism for improving human values.

Despite the disdain that many claim toward values as proper subjects for science, the ultimate aim of science is pursuit of values. If religion is the general name for pursuit of values, then scientists who pursue values are religious. If Humanism is the religion most completely based on science—contemporary science, that is—then Humanism is the most scientific religion and the best religion for scientists. And, if so, most scientists today, whether aware of it or not, are Humanists.

LINES FOR A VERY YOUNG SCHOLAR

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DEPARTMENT OF MATHEMATICS, THE OHIO STATE UNIVERSITY

There is but one who may intrude unbid
When in my study I at last am rid
Of the world's clamor and the day's affairs.
Sometimes I hear him as he mounts the stairs
Or tiptoes to my door on stealthy feet.
But sometimes, when his triumph is complete,
He moves so softly that he gains my side
Without my knowing it, and stands with pride,
Still as a nesting bird, until my eyes,
Wandering a moment from my book, surprise
His own on me. And then without a smile
We face each other for a little while,
Revealing in our comic gravity
A mutual amazement, I to see
My boisterous son, all roughness put away,
And he to find the comrade of his play
So strangely occupied with quiet things,
Till with a burst of laughter up he springs
To his unchallenged throne upon my knee.

Dear little boy, how easy it would be
To lay the burden of my dreams on you,
And try to make you be, and think, and do
The things I cherish as life's highest aim.
But love has saved me from the patent shame
Of such conceit; I shall be guardian, friend,
All that a father should, but I shall send
A free man, not a slave, against the years
When you go forth. And where the road appears
Fairest to you, there with my blessing, go.
I shall be well content to have it so,
Knowing that you have gathered from this hour,
Often repeated, an imponderable dower,
More precious than any tangible resource,
A love of books, faith in the quiet force
Of clear, unbiased thinking, and the zest
Of kinship with all men who manifest
A love of truth, and make her cause their task.
These are a warrant for the thing I ask:
To see that you escape the deep distress
Of lasting failure or too cheap success.

A NEGRO SCIENTIST OF SLAVERY DAYS[1]

By GEORGE P. MEADE

COLONIAL SUGARS COMPANY, GRAMERCY, LA.

THE little-known story of Norbert Rillieux, Negro engineer, inventor, and scientist of ante-bellum days is scattered through textbooks on evaporation, sugar journals, and sugar reference books.

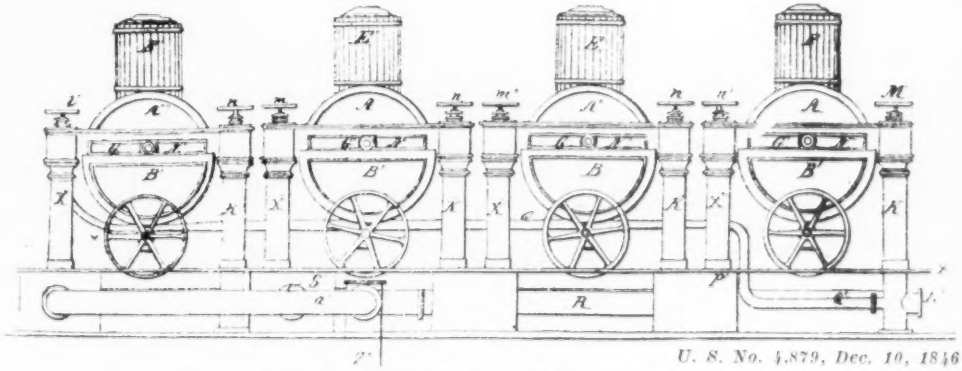
It is just 100 years since the first practical multiple-effect vacuum evaporator, known then as the Rillieux apparatus, was put into use in a sugar factory near New Orleans, and the centenary seems an appropriate time to bring together the facts concerning the inventor. Evaporation in multiple effect is now universally used throughout the sugar industry as well as in the manufacture of condensed milk, soap, gelatine, and glue, in the recovery of waste liquors in distilleries and paper factories, and in many other processes. The underlying principle on which these evaporators operate has not altered materially since Rillieux first designed his system, and a clear and simple description which applies to all such evaporators in use today is given in one of Rillieux's patents (U.S. 4,879, 1846):

> A series of vacuum pans, or partial vacuum pans, have been so combined together as to make use of the vapor of the evaporation of the juice in the first, to heat the juice in the second and the vapor from this to heat the juice in the third, which latter is in connection with a condenser, the degree of pressure in each successive one being less. . . . The number of sirup-pans may be increased or decreased at pleasure so long as the last of the series is in conjunction with the condenser.

The drawings accompanying the patent show that Rillieux's apparatus consisted of a series of horizontal pans, or bodies, with steam coils, also horizontal, each body having the general form of a locomotive boiler (Fig. 1).

The great scientific contribution which Rillieux made was in his recognition of the steam economies which can be effected by repeated use of the latent heat in the steam and vapors. The vapors resulting from the evaporation in the first body of the evaporator contain practically all the latent heat of the

[1] Special thanks are due Dr. Charles A. Browne, of the U. S. Department of Agriculture, for source material, illustrations, and suggestions in the preparation of this article. Mr. Alfred L. Webre, of the U. S. Pipe and Foundry Company, Burlington, N. J., also supplied valuable source material.



U. S. No. 4,879, Dec. 10, 1846

FIG. 1. RILLIEUX'S SECOND PATENT FOR EVAPORATING SUGAR SOLUTIONS IN VACUO. AN ELEVATION OF A SERIES OF EVAPORATING PANS.

original steam, and these vapors are carried over to the steam chest of the second body where they give up their latent heat to the liquid in this body, which boils at a lower temperature because of the reduced pressure. The process is then repeated from the second to the third body and so on until the vapors from the last body go to the condenser.

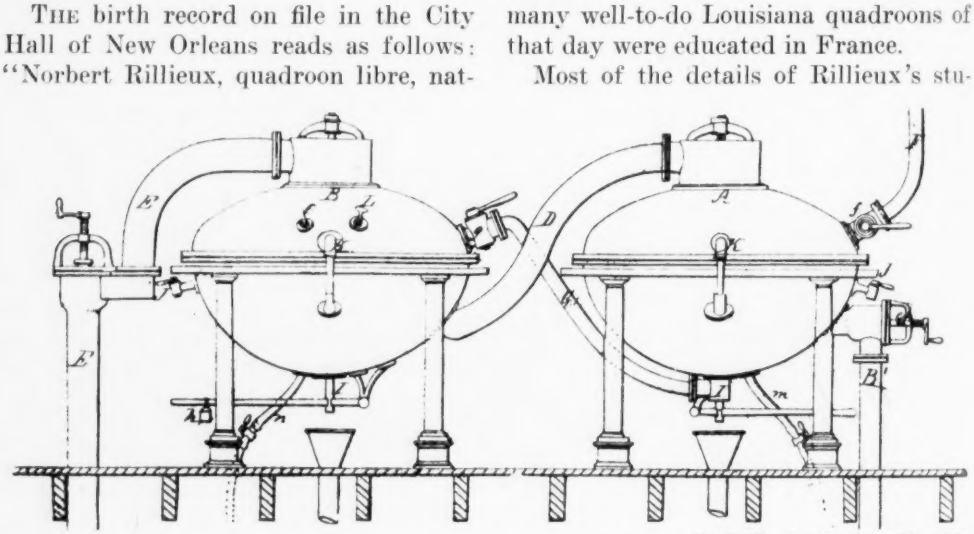
Theoretically, the multiple use of the latent heat may continue for any number of times, as is indicated in Rillieux's patent, but the practical application is limited by the need for sufficient temperature difference between the vapor and the liquid to be boiled. Quadruple effects are commonly used in the sugar industry, but higher combinations have been designed for special purposes. The multiple use of the latent heat results in economies proportional to the number of times that the transfer of latent heat is repeated, and the fuel savings which Rillieux's application of the principle have effected through the years are enormous.

THE birth record on file in the City Hall of New Orleans reads as follows: "Norbert Rillieux, quadroon libre, natural son of Vincent Rillieux and Constance Vivant, Born March 17, 1806. Baptized in St. Louis Cathedral by Pere Antoine."

It is not known whether the child was specifically freed or whether his mother was already free, but the latter is the more probable. The term quadroon was commonly used to mean any person who was more than half white, and the indications are that Norbert Rillieux was only one-eighth colored blood. The fact that the baptism took place in the cathedral and that the father's surname was given him and not the mother's may have been usual for such alliances at that time.

The father, Vincent Rillieux, was himself an engineer and inventor. A steam-operated cotton-baling press which was installed in a cotton warehouse on Poydras Street was one of his inventions of sufficient merit to be mentioned in the notes published at the time of his more distinguished son's death. The father recognized the boy's ability at an early date and sent Norbert to Paris to be educated. This was not unusual as many well-to-do Louisiana quadroons of that day were educated in France.

Most of the details of Rillieux's stu-



U. S. No. 3,237, Aug. 26, 1843

FIG. 2. RILLIEUX'S FIRST PATENT

FOR EVAPORATING SUGAR SOLUTIONS: TWO HOWARD VACUUM PANS CONNECTED IN MULTIPLE EFFECT.

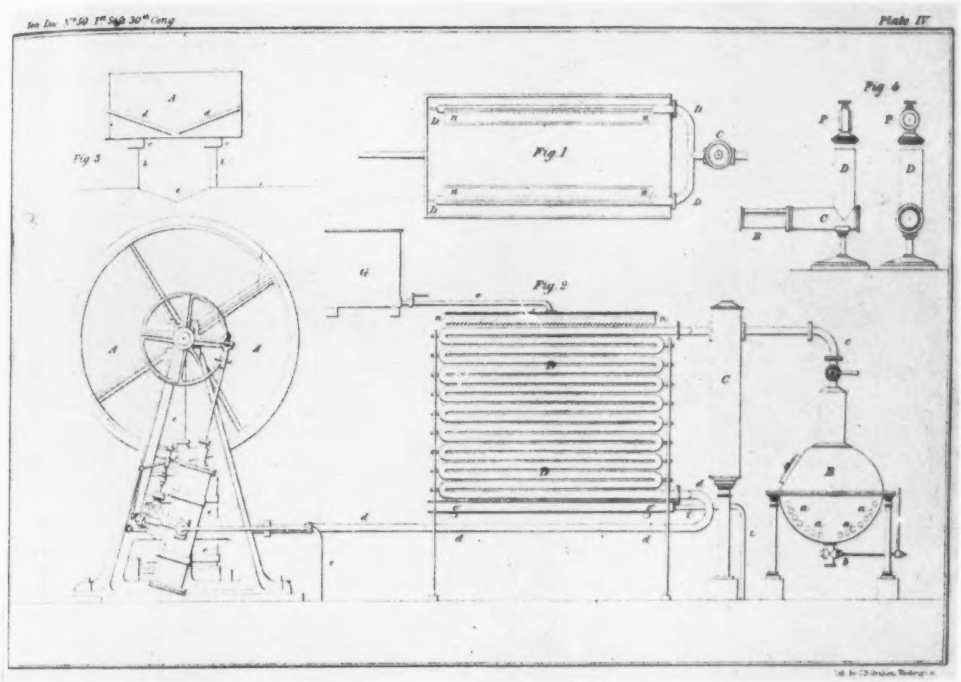


FIG. 3. CROSS SECTION OF A DEGRAND EVAPORATOR[2]

THE EVAPORATOR D STANDS BETWEEN VACUUM PAN B AND VACUUM PUMP A. SUGAR-CANE JUICE FROM G, TRICKLING OVER THE COILS OF D, CONDENSES THE VAPORS FROM B AND IS EVAPORATED TO A SIRUP WHICH IS THEN FURTHER CONCENTRATED IN B TO THE POINT OF CRYSTALLIZATION.

dent life in Paris come from the noted French sugar technologist and engineer Horsin-Deon, who was associated with the Louisianian in the latter part of the nineteenth century. Evidently the young Rillieux showed rare aptitude for engineering since at the age of twenty-four he was an instructor in applied mechanics at L'École Centrale in Paris. In 1830 he published a series of papers on steam engine work and steam economy, and, according to Horsin-Deon, it was at this time that he developed the theory of the multiple-effect evaporator. Unfortunately, none of these publications is now available but, according to French sources, they were of very high order.

[2] Plate IV of R. S. McCulloh's *Scientific Investigations in Relation to Sugar* and *Hydrometers*. Washington, 1848. Senate Document No. 50, 30th Congress, 1st Session.

The interest in multiple-effect evaporation was an outgrowth of Howard's invention in 1812 of the vacuum pan (Fig. 2) for boiling sugar solutions to grain. The advantage of vacuum evaporation for such a heat-sensitive material as sugar was so obvious that the "Howard saccharine evaporator," as it was called, was promptly adopted by the sugar refiners in England for crystallizing their sugar liquors. This was a "single-effect" and it is the prototype of all modern vacuum pans that crystallize the world's sugar. Many inventors turned their attention to extending Howard's invention so that it would make use of the latent heat of the vapors. The most promising of these attempts was the evaporator of the French inventor Degrand, who condensed the vapors from the vacuum pan in a series of horizontal coils whose outer

surfaces were cooled by a falling film of clarified cane juice. This evaporator (Fig. 3), as manufactured by Derosne and Cail of France, was installed in Louisiana, Cuba, and other countries to a limited extent, and for a time was a competitor of Rillieux's apparatus. The evaporation of juice thus accomplished, however, was an imperfect utilization of the latent heat and it remained for Rillieux, by a stroke of genius, to enclose the condensing coils in a vacuum chamber and to employ the vapor from this first condensing chamber for evaporating the juice in a second chamber under higher vacuum. It was thus that young Rillieux established for the first time the principles that have "laid the foundation for all modern industrial evaporation." He tried without success to interest French machinery manufacturers in his invention, and nearly twenty years elapsed before a beet sugar factory in France installed a multiple-effect evaporator.

The reputation of the young inventor must have reached Louisiana, as he was called to New Orleans by Edmund Forstall to be chief engineer of a sugar refinery which Forstall was building. The arrangement lasted only a short while, as Rillieux abandoned his position to avoid displeasing his father, who had some disagreement with Forstall.

The first attempt at a practical evaporator was in 1834 on the plantation of Zenon Ramon, where Rillieux and two colleagues constructed a triple effect which is frequently referred to as the first multiple evaporator. Following this doubtful venture Rillieux plunged into speculation on lands and made "an enormous fortune" which was lost through a bank failure in the financial crisis of 1837. Another unsuccessful attempt to operate a triple effect was made in 1841, but the reasons for the failure are again vague.

Finally, in 1843, Theodore Packwood, who owned a plantation below New Orleans now known as "Myrtle Grove," interested himself in the invention and encouraged Rillieux to install a triple effect made according to Rillieux's designs by the manufacturing firm of Merrick & Towne of Philadelphia. This operated with complete success in 1845, and it is agreed by all authorities that this was the first factory-scale multiple-effect vacuum evaporator. Although Rillieux's first patent of 1843 (No. 3,237) consists simply of two Howard vacuum pans connected so as to work in double effect (Fig. 2), the Packwood installation is always referred to as a triple effect. The evidence is that this conformed closely to the design (Fig. 1) given in Rillieux's second patent of 1846 (No. 4,879). A study of the text of these patents shows that the inventor had a thorough grasp of both the theory and practice of multiple-effect evaporation as understood today.

The acclaim was immediate and widespread, and the Rillieux apparatus was promptly recognized as revolutionizing the manufacture and refining of sugar. In 1846 several other factories in Louisiana installed the new evaporating system which made a superior sugar at greatly reduced costs. First and second prizes for the best sugar were awarded that year to Packwood and to Packwood and Benjamin, respectively, both cited as having "Rillieux's patent sugar boiling apparatus." The picturesque but wasteful "Jamaica train," in which the juice was evaporated in a series of open kettles, gave way rapidly not only in Louisiana but in Cuba (Fig. 4) and Mexico. The progressive factory owners of Louisiana were proud of their new equipment, and the financial reports carried the notation "Rillieux system" after the production statistics of the factories so equipped. Thirteen sugarhouses were thus designated in DeBow's crop reports of 1849.

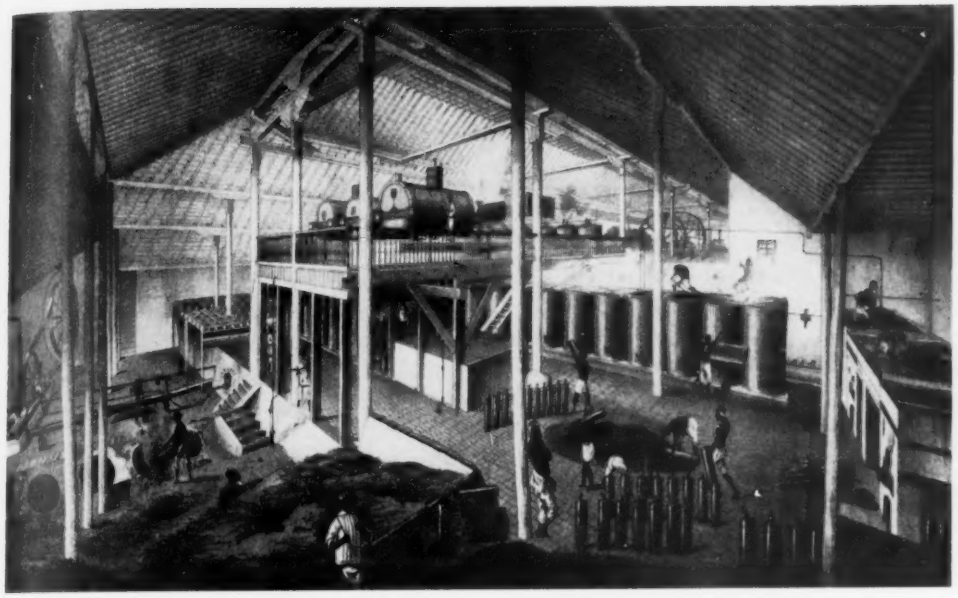


FIG. 4. INTERIOR OF A CUBAN SUGAR FACTORY[3]
INGENIO ASUNCIÓN, ABOUT 1855, SHOWING A RILLIEUX TRIPLE-EFFECT EVAPORATOR IN THE GALLERY.

The system as generally installed at that time included not only the multiple-effect evaporator for concentrating the cane juice to a sirup but also a vapor-heated vacuum pan for boiling the sirup to grain. The vapor for the pan was drawn from the first body of the multiple evaporator, and the boiling to grain was therefore done in multiple effect. This vapor vacuum-pan idea antedated by seventy-five years a similar arrangement of vapor pans in the large modern factory at Clewiston, Fla., which is looked upon as an innovation by present-day sugar factory engineers.

The years from 1845 to 1855 were years of triumph for Rillieux, or at least for his ideas. The new evaporating equipment was in sharp contrast to the older methods in which Negro slaves transferred the boiling juice from one steaming open kettle to the next by means of long ladles. One workman manipulating a few valves operated the completely enclosed Rillieux apparatus. In addition to the savings in labor and steam, the lower boiling temperatures *in vacuo* resulted in greatly reduced losses of sugar in the process. Possibly no such revolutionary change had taken place in any industry up to that time. This was not merely a change from a manual operation to a mechanical one; it was a complete overturn in theory, practice, and method from a process that had changed little through the centuries to one which was fundamentally the same as is used in the boiling-house of all sugar factories today.

FEW details of Rillieux's social status as a free man of color have come down to us. According to one story, he was housed in the slave quarters on some plantations that his work required him to visit, but this appears to be an exaggeration. Direct evidence from a man whose father knew Rillieux and employed him on his plantation as an engi-

[3] Copy of a lithograph by E. Laplante in J. G. Cantero's *Los Ingenios de la Isla de Cuba*, Havana, 1857.

neer indicates that the color problem was met by providing a special house with slave servants for the inventor on his visits as a consultant. According to this source, Rillieux was "the most sought after engineer in Louisiana," but because of his colored blood he could not be entertained at the owner's house or in the home of any white person.

Rillieux's own reminiscences, as transcribed through Horsin-Deon, do not refer to injustices because of his color, but there can be no doubt that he was subjected to restrictions and possibly indignities. Free persons of color were more and more restrained with the approach of the Civil War, although they never reached the status of slaves. Among other prerogatives, they had property rights; they could (and did) own slaves; and they were subject to taxation, even though they were deprived of the use of the New Orleans public school system. But by 1855 a free person of color could not move about the streets of New Orleans without permission, nor might he stop in the city without first presenting the guarantee of some white man. Failure to leave the city when ordered meant years of imprisonment at hard labor.

These restrictions probably contributed toward Rillieux's decision to return to France to live, although another argument for such a move would have been the rapid decline of the sugar industry in Louisiana during the war. The year of his leaving is in doubt. Horsin-Deon says that he left America "after the war, exhausted and asking for nothing but rest," but others refer to his living in Paris in 1861.

His engineering work while in Louisiana was by no means limited to the sugar industry. The drainage of the lowlands of New Orleans was one of the problems which he undertook, and a successful plan was worked out. There are conflicting stories about this enterprise. Horsin-Deon, who quotes Rillieux in much factual detail, says that the deal was blocked in the state legislature by Forstall, "his sworn enemy." It is not clear from this account whether the project was completed, or even attempted. Rousseve, in *The Negro in Louisiana* (New Orleans, 1937), says that the plan was a city sewerage system "which local authorities refused to accept" because "sentiment against free people of color had become sufficiently acute to prohibit the bestowing of such an honor upon a member of this group." The race question may have had some bearing, but this writer's source material seems to have been faulty as he credits Rillieux with inventing a "vacuum cup" and says further that "after a time he must have moved to France, for he is mentioned as head of the École Centrale of Paris."

Strangely enough, his patent troubles all occurred in Europe, where no race discrimination was involved. The United States patents are in the inventor's own name and were fully and profitably exploited by him during his last fifteen years in Louisiana. A fixed price was charged for the apparatus and in addition a percentage of the amount saved in fuel, which resulted in large returns to the inventor. A German who was working for the Philadelphia firm which constructed the first triple effect for Louisiana copied the drawings and took them to a factory in Magdeburg, Germany. From these pilfered designs, the first multiple-effect evaporator in France (and evidently anywhere abroad) was installed in 1852 in a beet sugar factory at Cuincy (Nord). This installation and several others made during subsequent years operated so poorly that the nickname *triste effet* became common among French sugar engineers. Authorities agree that the difficulty lay in a complete misunderstanding of Rillieux's designs, proving that the reason for the

success of the evaporators erected in America by Rillieux himself was his knowledge of the underlying scientific principles.

The first ten or fifteen years of his life after the return to Paris are obscured by lack of detail. He apparently lost all interest in sugar machinery and took up the study of Egyptology, working for at least a decade with the Champollions, who were noted specialists on the subject. According to an editorial in the *Louisiana Planter* at the time of Rillieux's death, Duncan Keener, one of the leading sugar planters of Rillieux's day in Louisiana, on a trip to Paris in 1880 looked up the inventor and was surprised to find him assiduously deciphering hieroglyphics at the Bibliotheque Nationale. This is further evidence of Rillieux's studious mind and scholarly attainments.

When Rillieux was nearing his seventy-fifth year he "returned from the pyramids," as one French commentator put it, and again vigorously concentrated on the problems of evaporation and sugar machinery. In 1881 he patented a system for heating juice with vapors in multiple effect which is now universal practice in cane and beet sugar factories. This innovation which Rillieux made at such an advanced age was credited with reducing fuel consumption in French beet sugarhouses to one-half that before its introduction. In collaboration with Horsin-Deon, Sr., a cane sugarhouse was constructed in Egypt on the Rillieux system, using a quintuple-effect evaporator for juice, a double-effect vapor vacuum pan for boiling sugar to grain, and a triple-effect for juice and other heating. This factory employed the diffusion process, which gives very thin juices, and therefore fuel economies were of great importance. Many sugarhouse engineers of today do not realize that such an extensive use of steam in multiple effect was fully developed over sixty years ago. This combined process of juice heating, vapor boiling to grain, and multiple-effect evaporation seems to be the French process patent which Rillieux lost because "experts were unwilling to recognize his invention." He was then eighty-five years old but of active temperament and in full possession of his faculties. The loss of his process seems to have been too much for the old man, however, and he ceased to devote himself to this work to which his genius had contributed so much. He died in his eighty-ninth year and, according to his unflagging friend Horsin-Deon, the "end came more from a broken heart than from the weight of years." He was buried in a vault in the churchyard Pere La Chaise with the following inscription on his grave:

Ici reposent
Norbert Rillieux
ingénieur civil a la Nouvelle Orleans
18 Mars 1806
décédé a Paris le 8 Obre 1894

Emily Cuckow, Veuve Rillieux
1827–1912

Little is known of Madame Rillieux except the dates on this headstone and that she was in comfortable circumstances during the final years of her long life.

Rillieux's character and appearance have been variously described, principally by French commentators. An excellent photograph taken in his later years in Paris shows him as a rather imposing figure of Caucasian appearance, with a high forehead, luxuriant white hair, and a mustache and full beard trimmed in French style. A vigorous and intense disposition, forceful to the verge of impatience, was evidently his, as the editor of a technical paper in Paris speaks of Rillieux's criticisms of his competitors as "formulated with a vivacity quite in character with

Norbert Rillieux

the irritable inventor." Apparently the term *caractère difficile* was frequently applied to him, since the younger Horsin-Deon denies that this is correct but adds that he was a *combatif* throughout his life, excessively frank, saying exactly what he thought, and never countenancing either duplicity or injustice.

THE recognition which Rillieux has received is surprisingly contradictory. On the negative side, there is no reference card bearing his name in either the New York Public Library or the New Orleans Public Library. None of the encyclopedias carries anything about him. The *Dictionary of American Biography*, which includes the names of Western bad men, gamblers, baseball players, football coaches, and relatively obscure inventors, does not mention this man whose apparatus revolutionized the sugar industry.

Most writers who have devoted themselves to the study of Negro life and Negro history afford him very little space. Rousseve (*The Negro in Louisiana*) gives only one paragraph to Norbert Rillieux, most of which is devoted to the story of the sewerage system already mentioned, but at least three pages are devoted to Victor Ernest Rillieux, a poet, whose work is little known. Thomas C. Fuller in the *Pictorial History of the American Negro* (Memphis, 1933) says "some authorities give Norbert Rillieux credit for inventing an evaporator pan by which the refining of sugar was completely revolutionized." Carter Woodson in *The Negro in Our History* (Washington, 1922) gives a full-page drawing of Rillieux's apparatus which is a facsimile of a page from the patent of December 10, 1846, but the only reference in the text is that "Norbert Rillieux, a man of color in Louisiana, patented an evaporating pan by which the refining of sugar was revolutionized." Weatherford does not mention Rillieux in *The Negro from Africa to America*, although this is the most frequently consulted work on Negro progress and achievements, according to the New Orleans Public Library.

The positive recognition is impressive. The only one of his race who seems to have accorded Rillieux full credit is R. L. Desdunes, himself a quadroon, in *Nos Hommes et Notre Histoire* (Montreal, Canada, 1911). After saying that the vacuum evaporating apparatus which he invented revolutionized the sugar industry (a line which all the other writers on Negro history seem to have copied), Desdunes states: "We have had our heroes, writers, musicians, painters, sculptors, and architects, but Rillieux himself was a scientific genius."

This appears to be the earliest printed reference to Rillieux's Negro extraction, aside from the birth record, although his racial background was common knowledge while he was living in Louisiana.

At the time of his death in 1894 the *Louisiana Planter and Sugar Manufacturer*, organ of the cane sugar industry for more than half a century, gave generous space to Rillieux's life and accomplishments. The editor and founder was John Dymond, a sugar planter, who operated one of Rillieux's original evaporating systems in his Belair sugarhouse until the factory was destroyed by fire in 1908. This apparatus was unquestionably the last of the early Rillieux equipment to operate in this country. The *Planter* ran a column-and-a-half editorial in the issue of November 3, 1894, and a two-column translation of an article which appeared in *Le Journal des Fabricants de Sucre* of Paris. The issue of November 24 carries the long letter from Horsin-Deon, Sr., in both French and English, from which much of the data here given have been taken. None of these articles makes any reference to Rillieux's Negro blood.

The editorial says: "It is almost startling to see the clearness with which Mr. Rillieux worked out his conclusions. There were so few people who appreciated what he was doing that it became necessary to accept his apparatus, we may say, blindly, its efficient working being accepted by many planters who had no comprehension of its *modus operandi.*" He was referred to as "one of the most distinguished engineers that has ever been identified with the sugar industry," and as "grasping this problem" of multiple-effect evaporation "with his superior intelligence." The editorial says further that "he went into the matter [of the repeated use of latent heat] so long in advance of our modern scientists such as John Tyndall, Lord Kelvin, and others that his success was a far more wonderful thing than can be grasped by those of this generation." These statements are not quotations from friendly French sources but the considered opinion of the editor who was operating Rillieux's equipment on his own plantation and who knew scores of Louisiana sugar men who had seen the pioneer development of the multiple-effect evaporator.

Sugar technologists have generally been generous to Rillieux. One of the earlier writers, J. G. McIntosh, in his *Technology of Sugar* (London, 1903), gives five pages to the development, principle, and advantages of the Rillieux patents. "This is the system which constitutes the basis of all the saving in fuel hitherto effected in sugar factories. . . . Rillieux may, therefore, with all justice, be regarded as one of the greatest benefactors of the sugar industry." McIntosh also credits him with originating many engineering accessories now in use, such as the catchall to prevent the carrying over of sugar from one body to another by droplets in the vapors, the sight glass, or lunette, for watching the progress of the evaporation in the vacuum apparatus, and the substitution of cast-iron vessels for the costly copper which was previously thought to be essential for sugar evaporation.

This extensive recognition by McIntosh is especially noteworthy because some European writers on beet sugar manufacture have considered only the first faulty evaporators in Europe which, though they did not actually bear Rillieux's name, were copies of his successfully operating models in America.

Among American authorities, Charles A. Browne, eminent sugar chemist of the U. S. Department of Agriculture, who has supplied much of the source material for this article, says: "I have always

held that Rillieux's invention is the greatest in the history of American chemical engineering and I know of no other invention that has brought so great a saving to all branches of chemical engineering."

Alfred L. Webre, a specialist in the field of evaporation, is convinced that Rillieux was the originator of the basic theory and practice and that he was fifty to seventy-five years ahead of his time with many of his ideas. W. L. Badger, of the University of Michigan, who is another recognized authority, says: "There is no question that the first multiple-effect evaporator to be actually built and commercially operated was built by Norbert Rillieux in Louisiana in 1843, covered by U. S. Patent No. 3,237." (The first year of operation was 1845.) Edward Koppeschaar, a Dutch specialist who published a treatise on evaporation in 1914, was so impressed with Rillieux's claim to distinction in this field that he inaugurated a movement about 1930 which resulted in the crowning recognition for Rillieux. Koppeschaar enlisted the support of the great Dutch sugar expert, H. C. Prinsen-Geerligs, then president of the International Society of Sugar Cane Technologists, for erecting a memorial to the Louisianian, and together they canvassed the sugar interests of the world for contributions. The response was almost unanimous and the only detractors were a few German scientists interested in beet sugar, who argued that Rillieux's claims as an originator were not fully established. The list of thirty-eight contributors covers the globe and includes organizations representing every cane and beet sugar producing country or territory.

A bronze plaque was designed and cast in Amsterdam, and arrangements were made through Dr. Browne to have this placed in the Louisiana State Museum, which is housed in the old *Cabildo* in New Orleans. The tablet shows a bust of the inventor in bas-relief with "Norbert Rillieux, 1806–1894" cast in the bronze. In a frame of tiles, also made in Holland, is the inscription:

To honor and commemorate
Norbert Rillieux
born at New Orleans, La., March 18, 1806, and
died at Paris, France, October 8, 1894
Inventor of Multiple Evaporation and its
Application into the Sugar Industry
This tablet was dedicated in 1934 by
Corporations representing the Sugar Industry
all over the world

The date of his birth on his grave and on this tablet does not correspond to Rillieux's birth record in New Orleans. The use of the word "corporations" in the inscription is somewhat misleading as the contributors were scientific and technological organizations and not commercial corporations.

A comparison with George Washington Carver will undoubtedly suggest itself. While it is not necessary to dim the luster of Carver's name in order to enhance the standing of Rillieux, it should be said that Carver's color and picturesque background undoubtedly added to his fame, whereas Rillieux has received little recognition from the general public, and this is in part, at least, due to his Negro extraction.

COAL BALLS—A KEY TO THE PAST

By HENRY N. ANDREWS

MISSOURI BOTANICAL GARDEN, ST. LOUIS

More than 200 million years ago vast areas of the United States, from what is now Massachusetts to Kansas, were covered with low humid swamps—a "Great Dismal Swamp" on a magnificent scale. There is no sound basis for the belief that it was necessarily a steaming tropical jungle as we are so often led to believe, but it certainly was composed of a lush growth of plants most of which would appear weird and strange to a modern field botanist.

In the stagnant swamp waters there accumulated a vast quantity of plant debris, most of which partially decayed and became compressed to form the plant-mineral we call coal. A microscopic examination of this all-important natural resource rarely reveals any distinguishable plant structure other than spores and pollen grains, yet by indirect methods we have learned a great deal about the vegetation that was responsible for it. This information has been gleaned very largely from *coal balls*, aggregations of petrified plants found in the coal seams of Midwestern mines.

Through southern Illinois, to select a typical and productive hunting ground, the coal seams often lie within 20 to 50 feet of the surface of the ground, and if they are thick enough it is profitable to employ the open-pit, or "stripping," method of mining. Gigantic electric shovels, scooping up as much as 25 to 30 cubic yards of earth and rock at a time, clear away the overburden, laying bare the coal below. In exploring such an exposed surface we might, with a little luck, chance upon characteristic rounded knobs projecting a few inches above the level of the seam as a whole. Upon digging down into the coal a few inches we find these knobs to be brownish ball-shaped masses of petrified plants.

These petrifactions are called coal balls because of their more or less rounded shape and because they are found in the coal itself. They contain a heterogeneous assemblage of petrified plant remains—stems, seeds, leaves, and other plant organs, often in a nearly perfect state of preservation. They are representative fragments of the millions of tons of forest debris that served as the raw material for coal. Our knowledge of the origin of these fossils is by no means complete, but the essential steps in their formation seem clear—at least in a general way. During Upper Carboniferous times streams of water heavily charged with minerals seeped through the swamps. Scattered here and there fragments of plants served as a nucleus for the deposition of the minerals, and the resulting petrifaction prevented their being crushed and altered into coal.

The coal balls are local in occurrence and as sporadically distributed. One may wander along an exposed seam for half a mile or more and not find one, then patches often covering many square yards will turn up. Where there are any at all there are hundreds of pounds, or even tons. In some mines they are never found and in others they are the usual thing. Incidentally, they are a bane to miners, for in addition to dulling drills they will not burn and must be screened out before the coal is loaded for market. In size they vary from specimens smaller than a thimble to huge ones almost too heavy to lift.

It is fitting to point out that this mode of fossilization is quite different from

that of the famous nodules of northern Illinois, discussed in "Fossil Plant Miniatures of Mazon Creek" by Raymond E. Janssen (THE SCIENTIFIC MONTHLY, March 1945). Although both are concretionary in nature—that is, built up by continued deposition of mineral matter about a central nucleus—the Mazon Creek concretions are found in the shales above the coal and contain as a rule but one compressed plant fragment. On the other hand, the coal balls occur in the coal itself and are continuous masses of plant parts preserved in cellular detail. They offer a special problem for study, but yield correspondingly greater botanical knowledge.

Since these are a unique type of fossil, as well as one that has added an amazing chapter to our knowledge of the Coal Age forests, it may be of interest to outline briefly the procedure that the paleobotanist follows in order to extract from them their secrets of the past (Fig. 1).

The coal balls are cut in half with a diamond-impregnated saw, and with a specimen 3 to 4 inches in diameter this is a matter of as many minutes. Next, the cut surface is smoothed with carborundum abrasives of #100 and #400 and then dipped into dilute hydrochloric acid. The acid will dissolve out the mineral matter (chiefly calcium and magnesium carbonate), leaving a very thin layer of the unaffected plant tissues standing in relief. This etching time varies with the strength of acid em-

FIG. 1. COAL BALLS FROM AN ILLINOIS MINE

A FRAGMENT OF A LARGE SHEET OF SPECIMENS SHOWING THEM EMBEDDED IN COAL. NATURAL SIZE.

FIG. 2. A SMALL TWIG OF LEPIDODENDRON
A CROSS SECTION SHOWING PERIPHERAL LEAF BASES AND CENTRAL CYLINDER. MAGNIFIED 15 TIMES.

ployed and the relative amount of mineral matter present. After the etched surface is washed and dried a solution of *parlodion* is poured over it and allowed to harden overnight. In the morning the resulting film is peeled off, using a razor, and with it comes a thin section of whatever plants have been exposed.

From the great open-pit Pyramid Mine south of Pinckneyville, Ill., we have collected tons of coal balls during the past five years. These have revealed a wide variety of plants, although a species of *Lepidodendron* is by far the most abundant (Figs. 2, 3). In fact 90 percent or more of the petrified vegetable debris of the coal balls consists of the stems, roots, leaves, and reproductive structures of this plant, suggesting that it probably composed a nearly pure stand in the forests of that region. The Lepidodendrons, although related to the modern diminutive Club-mosses of our eastern woodlands, were trees of respectable size, attaining a height of 60 to 70 feet and bearing a profusion of small needle-like leaves. Their superficial appearance was similar to that of a fir or spruce. The stem anatomy reveals some of the distinctive features of these trees. In proportion to the general size, the stem possessed little wood, depending for additional support on a tremendous growth of cork tissue. Since this cork composed a considerable bulk of the stem and was less susceptible to decay than most of the other tissues, we may conclude that it is the chief constituent of the coal of this region, and this conclusion is substantiated in other ways.

The quality of preservation in the coal balls from any mine varies a good deal, depending on the extent to which the plants decomposed prior to fossilization,

FIG. 3. SPORES FROM A LEPIDODENDRON CONE *Magnified 1000 times*

on the degree of replacement by the mineral, and on the nature of the mineral itself. The chief curse of the coal ball hunter is iron sulphide. Some specimens are composed almost entirely of it and in such cases they are of little or no botanical value. Specimens containing small quantities of iron sulphide are workable and may contain well-preserved plants, but in general they are distinctly inferior to those petrified by calcium and magnesium carbonate only. The "sulphur balls," as they are referred to by the miners, are excessively heavy and readily distinguished in the field in this way.

The perfection of preservation of relatively delicate plant tissues is a never-ceasing marvel to the uninitiated and to the professional paleobotanist alike. One of the most striking cases we have encountered is the presence of beautifully preserved fungus mycelium in the cortical cells of a fern stem (Fig. 4). The vegetative filaments (mycelium) of fungi are of common occurrence in petrified plants, but in this instance the mycelium had profusely invaded many of the host cells in a way strongly suggesting the mycorrhizal relationship in living plants. A vast number of modern perennial plants are now known to be dependent upon such a fungal association for certain phases of their nutrition, and it is of interest to find that this association must be one of great antiquity.

Plant structures as delicate as root hairs have turned up on at least one occasion in the Illinois coal balls. The roots, stems, and leaves of plants assigned to the Cordaitales, ancestors of present-day conifers, occur frequently enough to suggest that they were second in numerical importance only to the

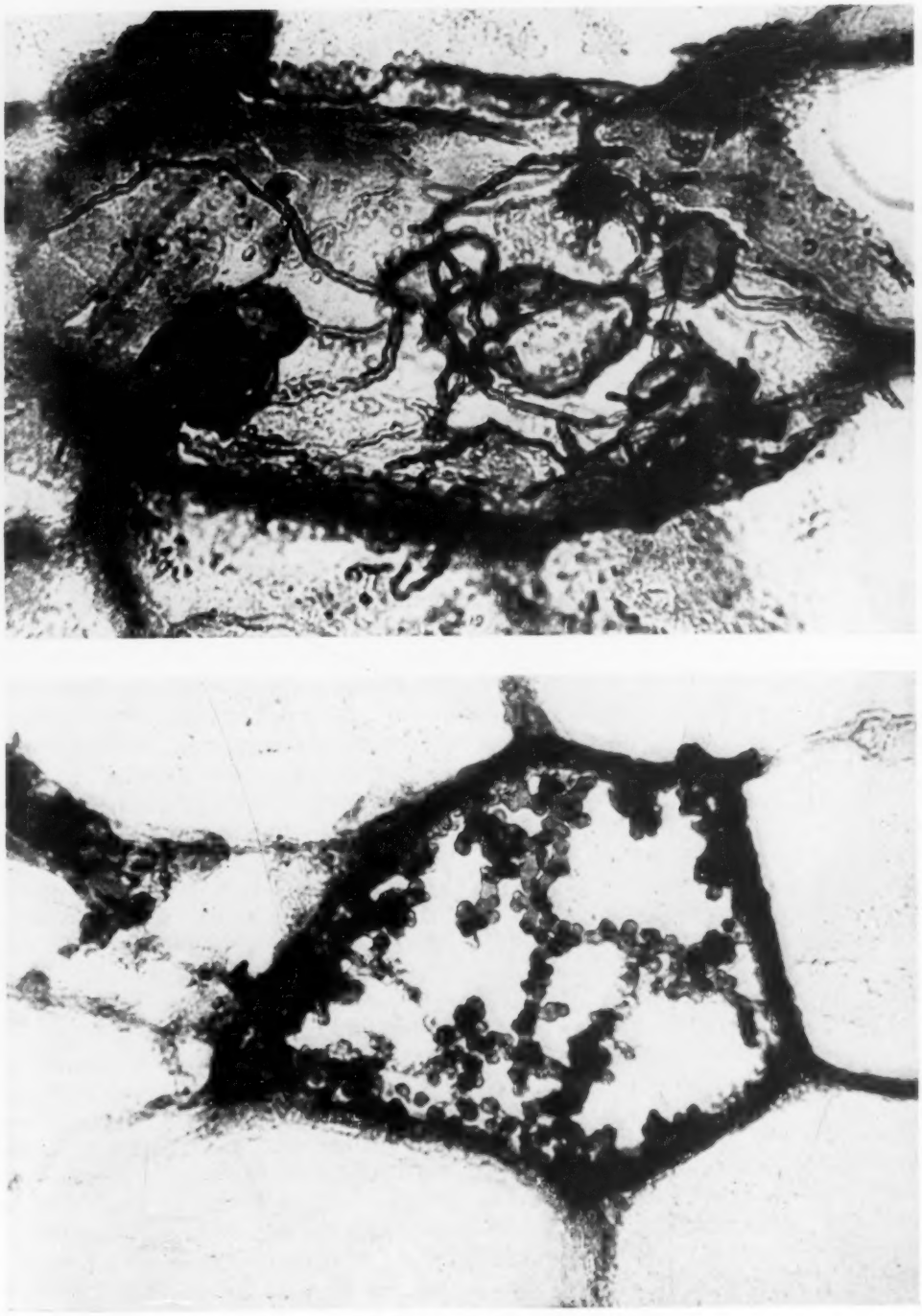


FIG. 4. FOSSIL FUNGUS MYCELIUM

SEEN IN CORTICAL CELLS OF A FERN FROM AN ILLINOIS COAL BALL. MAGNIFIED ABOUT 500 TIMES.

FIG. 5. A SEED-FERN STEM FROM IOWA

THIS CROSS SECTION OF *Medullosa Thompsonii* SHOWS THREE STELES COMPOSING THE CENTRAL CONDUCTING SYSTEM OF THE PLANT AND A LEAFSTALK DEPARTING AT THE RIGHT. MAGNIFIED 1.7 TIMES.

Lepidodendrons. They were trees that attained a height of 80 to 100 feet and bore long strap-shaped leaves, presenting a close superficial similarity to the foliage of iris or corn. In one of our earlier collections from the Pyramid Mine a stem was found with roots in organic connection, and some of the smaller rootlets retained their epidermal root hairs sufficiently preserved that they might well be used to demonstrate the salient structural features to a student in an elementary botany course.

Contrary to what might be expected, the more fragile plant tissues are often better preserved than the more resistant ones. The integument, or coat, of a seed, likewise belonging to the cordaitean group, found recently, is typical. It consists of three distinct layers: an outer one of large thin-walled cells, probably quite fleshy in life, and two inner layers, the cells of which had walls that were thick to the point of being stony, much like the "grit" tissue of a pear. The outer tissue was very well preserved whereas the inner two had become rather badly decomposed prior to fossilization. This is by no means an isolated case, and the explanation seems clear when one reviews the probable sequence of events. The mineral-bearing waters were able to penetrate the thin-walled cells much more rapidly than the sclerotic ones, thus insuring their petrifaction before bacterial and chemical decomposition set in to any appreciable extent.

As might be expected, the flora of the coal balls varies somewhat from place to place. For example, specimens gathered in the vicinity of Des Moines, Ia., reveal a different Carboniferous landscape from the Illinois mines a few hundred miles to the southeast. In Iowa, seed plants seem to have been dominant, including members of the Cordaitales, and a considerable variety of species belonging to that most fascinating of all extinct fossil groups, the Seed-ferns, or Pteridospermeae (Fig. 5). This does not imply, however, that the plants composing the two floras were entirely different, for in nearly all Upper Carboniferous deposits from Kansas and Iowa, east to China, there occur certain common genera of Lycopods and Calamites and a wide variety of fernlike foliage. Some of the latter we know belonged to true ferns, a few have proven to be Seed-fern fronds, and the affinities of a great many remain in question.

The abundance of this fernlike foliage

that is found almost everywhere in the shales that overlie coal deposits of Pennsylvanian age has led to numerous learned monographs. Unfortunately much of it is sterile, offering no recognizable clues as to its natural relationships. A suggestion began to grow in the minds of paleobotanists during the latter part of the eighteenth century that these apparent ferns may have borne seeds. The evidence, however, was not forthcoming until about 40 years ago, and in more recent decades a number of these "ferns" have been found to be Seed-ferns, presenting a multitude of distinctive characters, especially in the anatomy of their seeds and stems.

In the Iowa coal balls we have found a number of new and unique Seed-ferns, as well as specimens the same as, or closely related to, previously described European species. Of particular interest is the genus *Medullosa*, distinguished by having more than one woody cylinder, or "stele," composing the central part of the stem. And like the Lepidodendrons their wood-producing ability was not sufficient to support a great weight. In lieu of this the outer cortex developed a stout layer of tissue composed of anastomosing, vertically aligned strands of fibrous cells. The seeds of these plants are similar in certain respects to those of modern cycads, having a well-developed pollen chamber near the apex of the seed, in which the pollen grains apparently germinated and produced their male sex cells (Fig. 6).

FIG. 6. A FOSSIL SEED
IN THIS LONGITUDINAL SECTION NOTICE THE POLLEN IN THE TOP CHAMBER. MAGNIFIED 25 TIMES.

THESE calcareous concretions have been known for nearly a century from the coal fields of northern England. The earliest authors who gave a clear account of the petrified plants found within them were Joseph D. Hooker and E. W. Binney in 1854. Later in the century the works of W. C. Williamson began to reveal the extent of the prolific treasure of ancient plant life contained in coal balls, and his work was carried on by the late D. H. Scott, to whom we are indebted for a rich series of contributions on Paleozoic botany as well as an encyclopedic, yet very readable, text on the anatomy of fossil plants. In more recent years these petrifactions have been found in the Dutch, Belgian, and Russian coal fields.

In this country coal balls were discovered in a mine near Des Moines, Ia., as long ago as 1894. They apparently were not then brought to the attention of paleobotanists and consequently remained as dormant as before until years later. About 25 years ago the late A. C. Noé, of the University of Chicago, initiated the first productive interest in coal balls in America through their discovery in open-pit mines through central and southern Illinois. They have since turned up in a number of adjacent states, including Indiana, Kentucky, and Kansas, but the better preserved and largest collections to date have been obtained from Iowa and Illinois. We still lag considerably behind the great contributions of the British paleobotanists. There is now, however, a great deal of active interest in these American deposits which have already yielded such an abundance of beautifully preserved plants of the past.

THE SECOND LAW OF THERMODYNAMICS

A mountain range worn down may rise again,
Rivers and winds reverse their wonted flow,
Seas surge and sink, the glaciers come and go,
The distant mighty Cepheids wax and wane;
All these are local transitory show
To which the transient mind so fondly clings,
But entropy and time are endless things,
Immutable and changeless is their flow.

The Law predicts a dismal final state
The doom of this bright universe of ours,
Slowly downhill it drifts to meet its fate,
Reprieve nor hope is found in all its powers,
Darkness and death for all things surely wait
When change shall cease and no star marks the hours.

THOMSON KING

LEONARDO DID IT FIRST

By HARVEY N. DAVIS

PRESIDENT, STEVENS INSTITUTE OF TECHNOLOGY

"LEONARDO did it first" is a phrase familiar to scientists in many fields. Few of them may realize, however, that an interesting and comprehensive collection of Vinciana is assembled at Stevens Institute of Technology, where it is available for reference to scientists and scholars everywhere.

The Lieb Memorial Collection consists of about 2,400 items, including a complete set of the Leonardo manuscripts in facsimile. The few originals, of course, are preserved in the great museums of the world. Many of the facsimiles, issued in limited editions, have been long out of print and are almost unobtainable. In addition, an attempt has been made to secure every worth-while book or pamphlet on Leonardo in every language. This is a "scholar's collection, made by a scholar," accessible to all those interested in investigating the life, mind, and work of Leonardo da Vinci.

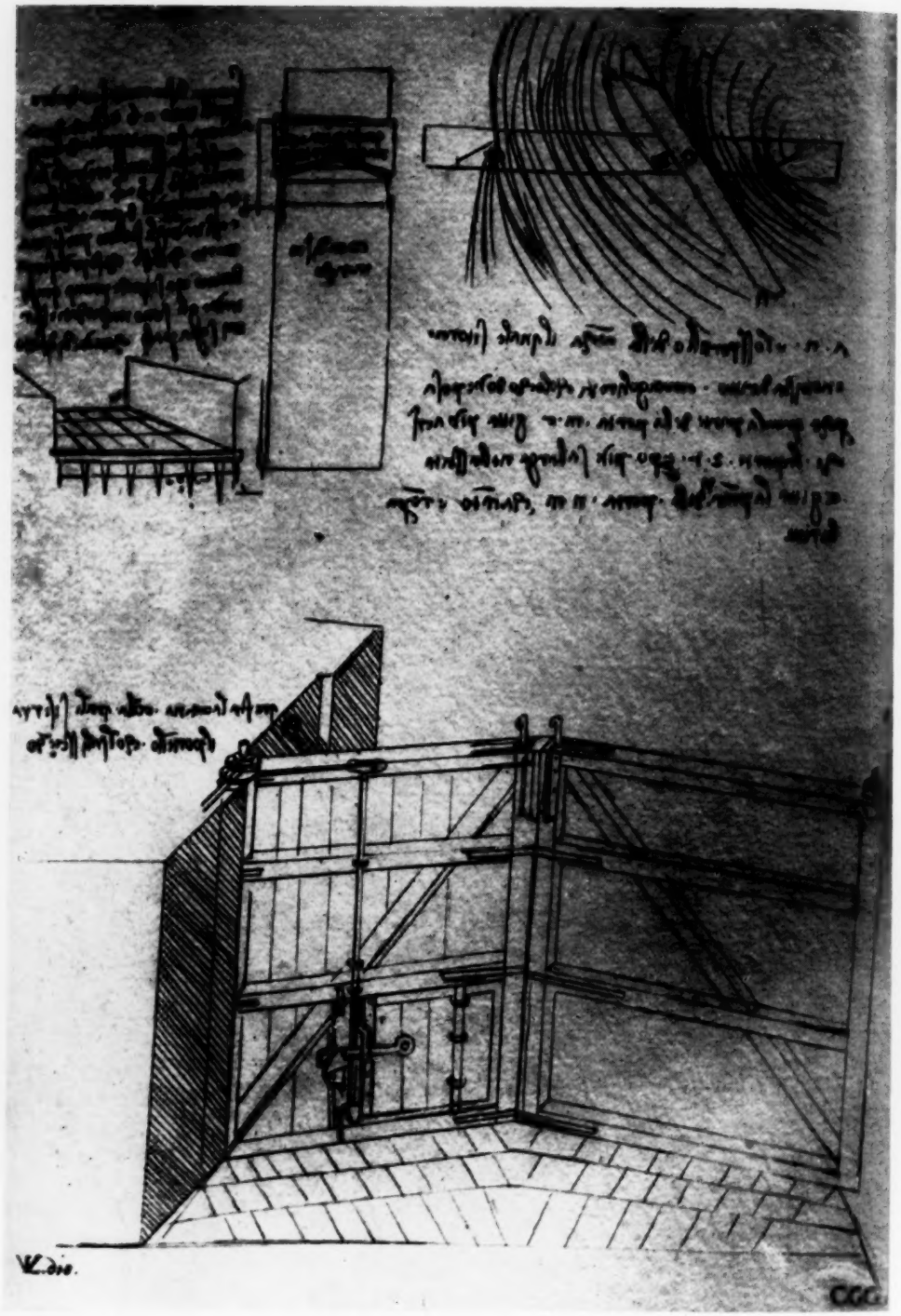
John W. Lieb, alumnus and trustee of Stevens, never knew that his collection was to have a permanent home in his own Alma Mater. There is no doubt that he would have been gratified to have it so. He thought of the collection as a nucleus of the history of science and art and wrote, a short time before his death, "I am very anxious that the collection should find lodgment in some public institution where it could be studied by engineers, scientists, artists, and professional men."

Lieb graduated from Stevens in 1880 and, after experimenting with the arc light in Cleveland for a year, became associated with Thomas A. Edison in 1881. Edison sent him to Italy to install the first Edison central station in that country. Lieb's assignment to Italy seems almost to have been predestined. In addition to doing a great job of engineering there himself, he was to rediscover a much older engineer and to make it possible for students all over the world to become better acquainted with that many-sided genius.

It was in 1890 that the Italian Edison Company, through Mr. Lieb, obtained a franchise from the Italian Government for the construction of a hydroelectric plant at Paderno on the River Addo. It was necessary, under the terms of the concession, to assume in perpetuity the maintenance of the Martesana Canal. This canal was to serve as the intake for the hydroelectric plant while serving as part of the extensive canal and irrigation system covering the plains of Lombardy.

When the bed of the canal was drained, it was found to be in perfect condition, and the locks at either end had been built in accordance with the best modern practice in hydraulic engineering. An examination showed that the original of these locks, identical with those then in use, had been built about the year 1500. The designer of these original locks was Leonardo da Vinci, who probably also laid out the plans for the canal itself. Amazed by the perfection of the system, Lieb devoted all his spare time to further research on da Vinci. In a remarkable way, he relived the life of his famous predecessor.

The result of his labors is the collection at Stevens. The Lieb Memorial consists of two research rooms and an exhibition room housed in the Stevens Library building, a square, brick, ivy-clad edifice erected in 1918, with a dignified inscription in stone, "The Lieb Me-



From Stevens collection of reproductions

LEONARDO'S LOCKS ON THE MARTESANA CANAL

morial," on the west door. The collection was purchased two years after Lieb's death and presented to the college in 1932 on a day fittingly chosen because it was the birthday of his lifelong associate, Thomas A. Edison—February 11. Fireproof rooms for the collection were provided by a fund raised by the late William S. Barstow, long a trustee of Stevens, and president of the Thomas Alva Edison Association. Besides the Leonardo collection the rooms house a historical collection of some 9,000 Stevens papers and a reference library on the work of Frederick W. Taylor (Stevens '83), originator of scientific management.

Although three rooms constitute the Lieb Memorial, one is dedicated principally to a library containing Lieb's collection of Vinciana. It is a small book-lined room, with filing cabinets at one end and a large desk in the middle. One-fourth of the collection pertaining to Leonardo constitutes the scientific material, which is concentrated at one end. The shelves are lined with books in English, French, German, and Italian. The famous "facsimilae" are bound in appropriate bindings and are large and impressive volumes. Reproductions of Leonardo's famous *Note Books* are kept in ivory-colored oversized folios, next to the maroon leather-covered *Codex Atlantico*.

In the large glass exhibition case in the middle room are some typical facsimiles of Leonardo's drawings in detail. There are a few choice reproductions of his paintings on the walls of the library room, including the famous self-portrait done in crayon.

In charge of the collection, as well as of the library proper, is Enid May Hawkins, who came to the college thirty-eight years ago as librarian, and who has had an influential part in the growth of the library and of its special treasures.

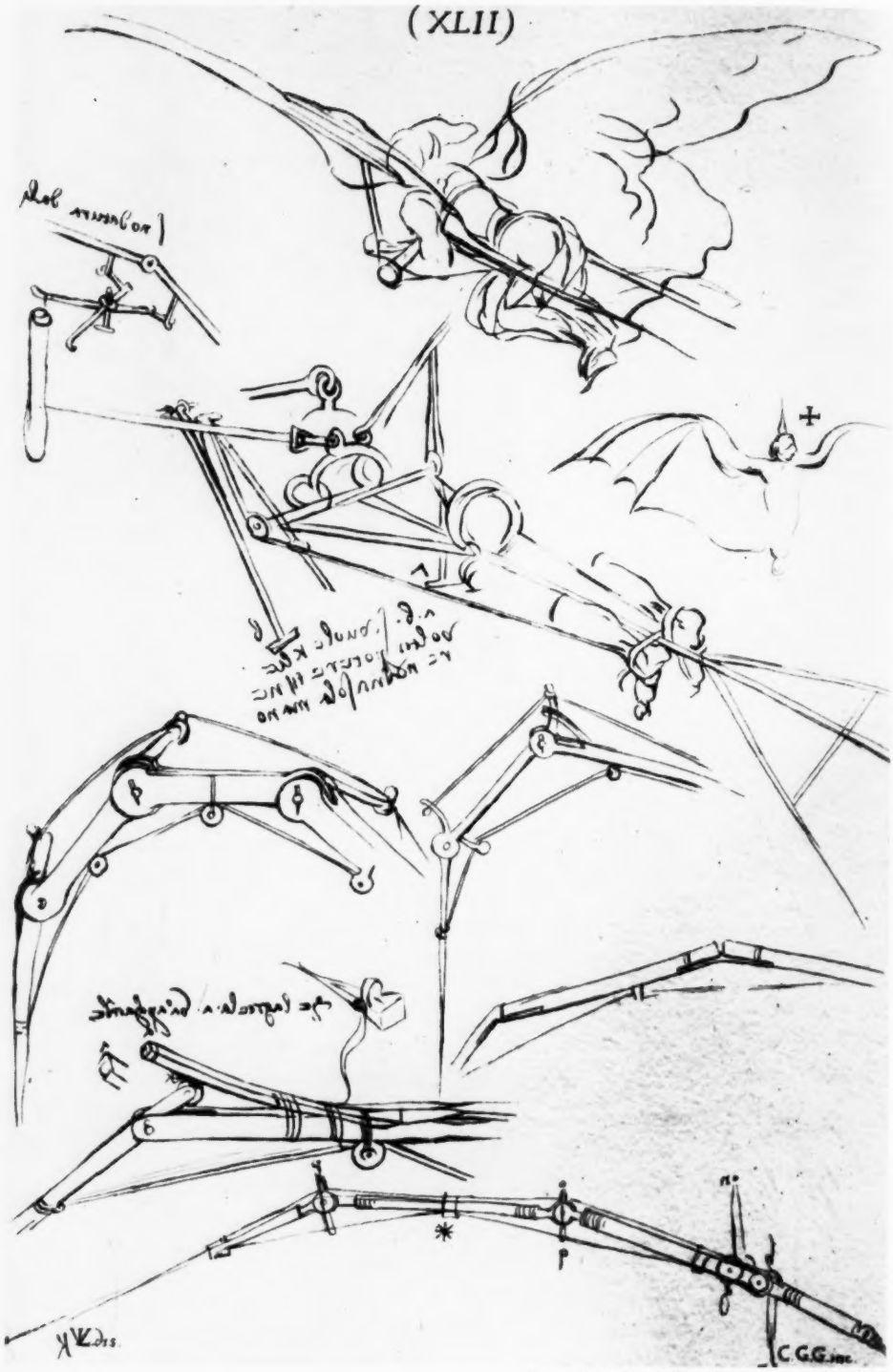
The entire collection is heavily insured, since it can never be replaced or duplicated. Many of the European houses that published the works went out of existence after the war began.

The oldest book of the collection, in its original binding of ivory-colored vellum, is the *Divina Proportione* by Paciolo Luca, published during the life of Leonardo and illustrated by him. A half-dozen scrapbooks containing clippings and magazine articles about Leonardo are kept in the files. The whole collection has been ably catalogued by Maureen Cobb Mabbott, a well-known Leonardo scholar, who says that this is probably the only collection of Vinciana made by an engineer with emphasis on Leonardo's mechanical genius.

He was ardently interested in every branch of theoretical or applied science in which any beginning had been made in his age (1452–1519) as well as in those in which he was the pioneer. He was full of new ideas concerning both the laws and applications of mechanical forces.

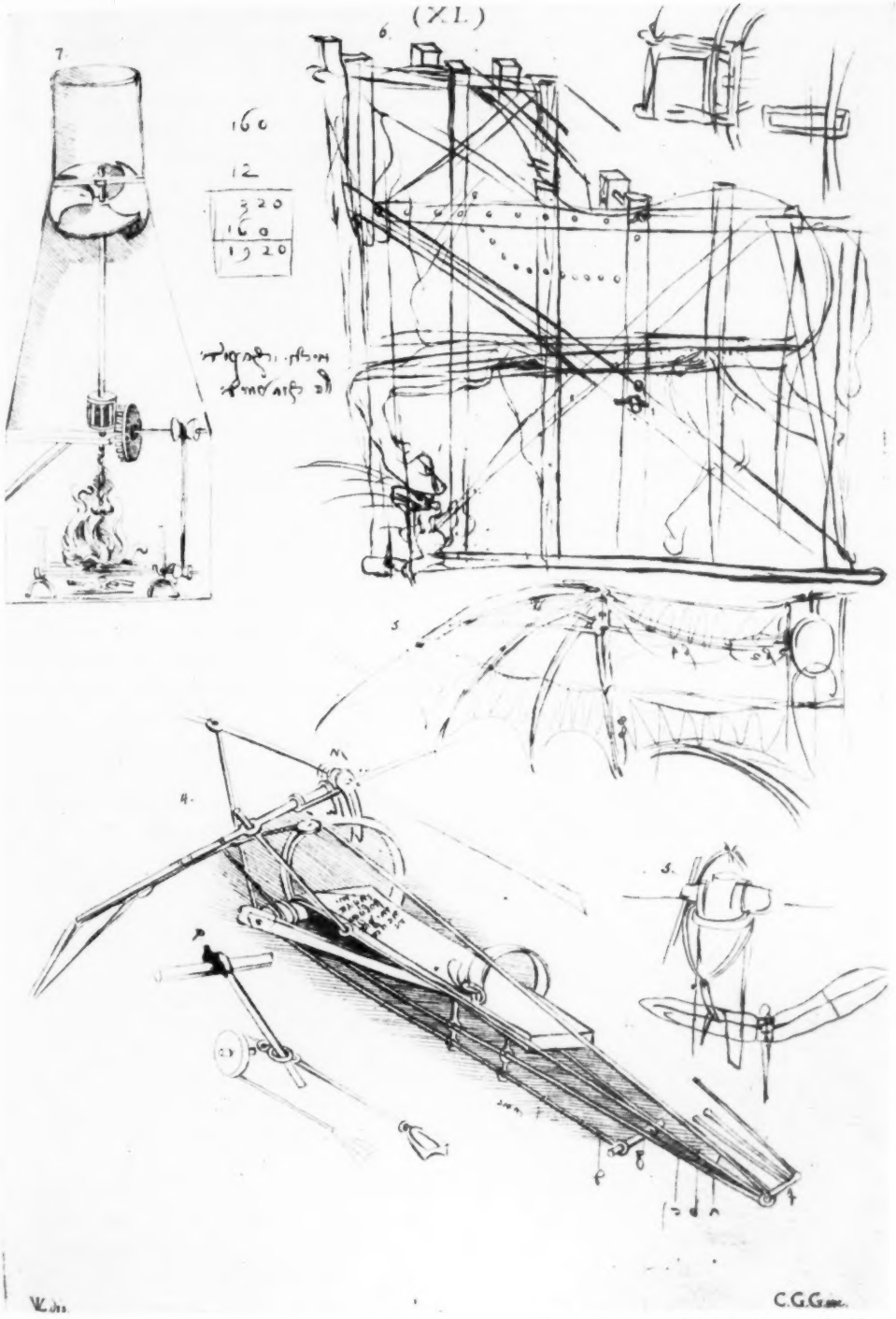
Only recently has the work which Leonardo did as a pioneer of physiological anatomy been appreciated. Copies of his anatomical sketches in splendid facsimile reproductions are to be found in the collection at Stevens. These consist not only of his beautiful and accurate drawings of the human figure, but also detailed studies of the internal structures: heart, lungs, and respiratory system.

Leonardo left over 6,000 pages of manuscript, almost all of it in "mirror-writing," each sheet covered with sketches. The small details of his work are fascinating to the engineer. For instance, he made a complete study of mills—arrangements for all sorts of power: wind, water, horse, mule, cranks, and various pumps. His drawings, no matter how technical, show that he was primarily an artist. They are often accompanied by minute drawings of hu-



From Stevens collection of reproductions

LEONARDO'S MECHANICAL ANGEL



From Stevens collection of reproductions

GADGETS OF THE RENAISSANCE

man beings, so real and anatomically perfect that they could serve as models in any drawing class.

To the scientist, however, his genius for mechanical invention is most important, and because of our recent concern with the instruments of war, it may be particularly interesting to recall his ventures in that field. At the age of thirty, Leonardo wrote a letter to the Duke of Milan, applying for work. He said, in part:

> I can construct bridges which are very light, strong, and very portable, with which to pursue and defeat the enemy. [This would certainly suggest the Bailey Bridge, of recent use.]
>
> In case of siege I can cut off water from the trenches and make scaling ladders and other similar contrivances.
>
> I can also make a kind of cannon which is light and easy of transport, with which to hurl small stones like hail. . . .
>
> I can noiselessly construct subterranean passages, either straight or winding, passing if necessary underneath trenches or a river.
>
> In times of peace I believe that I can give you as complete satisfaction as anyone else in the construction of buildings, both public and private, and in conducting water from one place to another.

Needless to say, he got the job! And kept it for sixteen years!

That Leonardo knew the principle of the submarine is evident in other notes. He contemplated an invention "to smash ships in the keel and sink their crews" and mentioned the existence of a machine by which many people could stay some time under water. Recently, when the moral issue relating to the use of the atomic bomb was raised, it was recalled that Leonardo had said, in respect to the submarine, that he would not "describe the method of it because the evil nature of man is such that it would be used as a means of destruction, namely, by assassinations at the bottom of the sea."

In spite of his many explorations into almost every conceivable field, Leonardo was haunted all his life by one great idea—the theory and practice of flight. "The Great Bird," he said, "will fly." His *Treatise on Birds*, one of the sources in the Stevens Library, has been an endlessly rewarding book to students of aviation.

Ivor B. Hart, in his *Mechanical Investigations on Leonardo da Vinci*, says: "Although he owed nothing to his contemporaries or those who lived before his day, careful studies of his manuscripts make it clear that Leonardo was not only a pioneer of flight, but the first pioneer." He also understood the theory of balloon flight but, as Hart says, "In the balloon there is neither life nor control." In "The Great Bird" of Leonardo's imagination there were both.

According to the same authority, Leonardo may well be credited with the first helicopter, and certainly with the first parachute. In Leonardo's own words, "If a man carry a dome of starched material eighteen feet wide and eighteen feet long he will be able to throw himself from any great height without fear of danger."

These are typical of what a student may uncover in the library at Stevens. What is more significant, he may learn that Leonardo's discoveries or inventions were always based on the scientific approach.

THE SUN MAKES THE WEATHER

II. WEATHER EFFECTS OF SOLAR VARIATION*

By C. G. ABBOT

RESEARCH ASSOCIATE, SMITHSONIAN INSTITUTION

EVERYBODY who undertakes to play with long programs of observing, seeking to know the effect of some supposed cause, likes to clear away from the figures he is using the effects of all well-known causes. Then his own supposed cause will have the field to itself. I therefore wish to clear the reports of temperatures I am about to use from the effect of night and day, and from the effect of summer and winter, before looking for the effects on temperature of the variation of the sun. Fortunately, the Weather Bureau has done this for me, for it publishes daily the average temperature for each 24 hours. That clears out the night-and-day effect. It has also computed, from the daily records of about 75 years, the expected normal temperature of each station for each day of the year. For example, at Washington, on Washington's Birthday, the normal average temperature is 36° F. On February 22, 1944, the actual average temperature was 44°. The difference was 8°. This +8° the Weather Bureau calls the "departure from normal temperature" for that day. Every month it publishes all of these "departures" for the individual days. It also publishes monthly average departures. In February 1944 it was +2.8°. As for precipitation, it publishes the amount of rain or snowfall from midnight to midnight for each day. At the end of the month it publishes the total precipitation for that month and the normal to be expected, from the average of records for that month for about 75 years. Thus in February 1944, 2.48 inches of precipitation fell. The normal for February is 3.37 inches. So the precentage of normal in February 1944 was 74.

Of the nearly 500 cases of short-interval changes of the sun's heat noted prior to the year 1940, about half were cases of *rise* and the other half of *fall*. They usually lasted about 3 days, and their average range was about 0.75 percent. As their effects would almost surely be different for different times of the year, I examined the temperature effects of these solar fluctuations in groups separately, month by month. In January of the years 1924 to 1939, I found 21 cases of rising, and 14 cases of falling, solar heat intensity. Corresponding to each rising case I wrote in a line the 20 Weather Bureau temperature departures for Washington, beginning 5 days before the sun's heat began to rise and continuing to 14 days thereafter. In this way I soon had a table of 21 lines with 20 columns of temperatures. I then took the average of each column. I did similarly for the 14 falling cases.

Most readers are familiar with the curves that newspapers publish so often, showing how stocks rise and fall, how prices of all sorts of goods change, how the population is meeting influences of many kinds, and, in short, how a multitude of things vary with time. Since this method is so well known, I use it in Figure 1, to show results for the months of January, February, and March. We find that small solar changes produce from 10° to 20° change in our Washington temperatures. The temperature changes for rising solar activ-

* Continued from page 210 of preceding issue.

ity are opposite to those for falling activity. The largest effects occur some 10 days after the solar changes seem to begin. The effects last through about 17 days, from 3 days *before* our measurements begin to show solar changes till 14 days *after*. I do not know why the weather effects start before our measurements begin to show solar change, but we do not yet know all that happens in the sun.

The other months give similar results, though they are not identical from month to month. All other stations behave as Washington does, except that the details of the effects differ from station to station. Similar details come a few days earlier at western stations, for weather, as we all know, drifts from west to east.

Our scientific critics, who "are from Missouri," have hitherto been reluctant to credit fully the day-to-day solar changes we have published. They praise the accuracy of our work, but doubt if it is accurate enough to show solar changes averaging only 0.75 percent, or even smaller. Hence I found it necessary to cite other people's observations of other solar phenomena in order to support these new and very important conclusions as to the weather effects of small day-to-day fluctuations of the sun's activity. I have used two such sources, both of which confirm our results as splendidly as one could wish.

One of these concerns the chemical element calcium, which exists in a very rarefied gaseous form in cloudlike masses high up in the atmosphere of the sun. These calcium clouds, named "flocculi" by the late Dr. George E. Hale, cannot be observed by telescope. They are revealed and photographed by an instrument called the "spectroheliograph," which Hale invented. The monks of the Jesuit solar observatory at Ebro have made such photographs, measured the areas of the flocculi, and published the results since 1910 for every day on which observation could be made. I computed from their measurements the changes indicated by the area of the flocculi and have used them as a measure of change in the sun's activity.

As another measure for changes in solar activity, I have used the measurements of the Carnegie Institution on ionization, made in Peru and Australia beginning in 1938. These were graciously furnished to me from manuscript by Dr. John A. Fleming, Director of the Carnegie Department of Terrestrial Magnetism. Electric ions are unit electric charges. They are shot out abundantly from sunspots and, traversing without hindrance the intervening space of 93,000,000 miles, they enter our atmosphere, where they multiply by breaking up, or "ionizing," the molecules of the gases of our upper air. They do not penetrate through the atmosphere to the earth to any great extent, but form layers of ions high above us. These are called, after two famous scientists, the Kennelly-Heaviside layers. It is these layers that reflect radio waves around the world. If they did not exist radio waves would go unhindered into space, and we would get no long distance programs.

The intensity of ionization in the principal ionic atmospheric layer, which scientists have named F_2, is measured every hour of every day at the two Carnegie observatories in Peru and Australia. During the night the values are small. As the sun comes up they greatly increase and remain high until sunset. I have taken averages of the values found in the daylight hours for every day available from 1938 to 1944. Fluctuations of my averages were at once apparent. They too, like the solar constant measurements and like the Ebro flocculi measurements, are in almost exactly the same relationship to the temperature departures at Washington

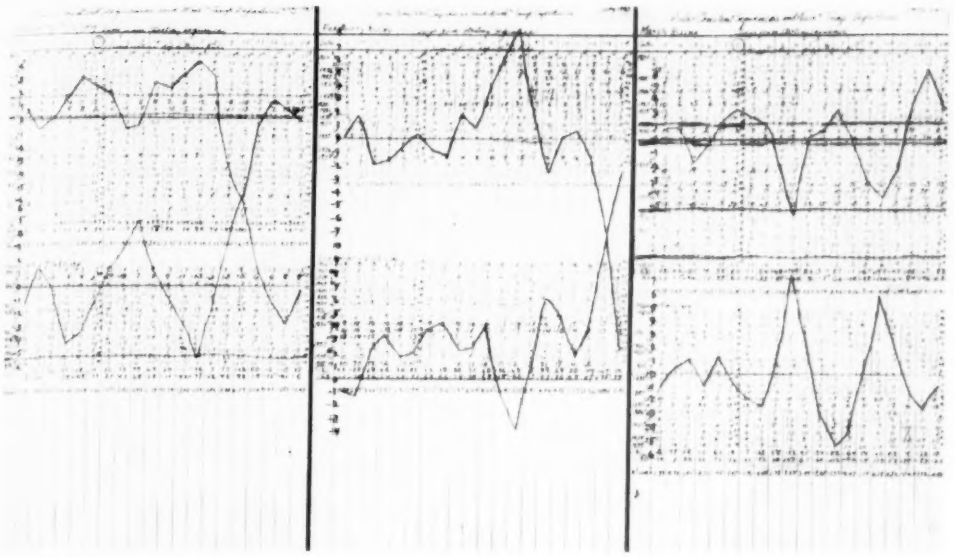


FIG. 1. SOLAR CONSTANT SEQUENCES AND TEMPERATURE DEPARTURES

AUTHOR'S WORKSHEET OF TEMPERATURE DEPARTURES IN WASHINGTON, D. C., DURING JANUARY, FEBRUARY, AND MARCH, SHOWING THAT RISING AND FALLING SOLAR ACTIVITY AFFECTS WASHINGTON TEMPERATURES OPPOSITELY AND STRONGLY FOR MANY DAYS. THE UPPER CURVES REPRESENT MEAN TEMPERATURE DEPARTURES ASSOCIATED WITH RISING SOLAR ACTIVITY; LOWER CURVES FOR FALLING ACTIVITY.

already described. So our work on short-interval solar variation and weather is confirmed from two quite independent sources, involving other years, other methods, other observers, other countries, and other phenomena.

And now comes the most suggestive result of all. Since these temperature changes are of importance until at least 14 days after the solar changes have been observed, there is in this new discovery ground to hope that certain weather features may be predicted for at least 10 days in advance. Ionization observations can be made on every day, rain or shine. Hence we must probably look to them for the groundwork of measurements on which to take this new important step in weather forecasting. I have, however, made a preliminary test of this new method, employing Smithsonian solar constant basic curves, such as those of curves 1 and 2 of Figure 1, and using Ebro photographs of solar flocculi to yield the dates when solar changes occurred. In order that I might immediately test the forecasts, I used months in former years, when the actual Washington temperatures were already available for comparison with expectation.

In Figure 2 solar predictions of Washington temperature departures for the months of September and October 1935, are shown by dotted lines, and the corresponding actually observed temperature departures by solid lines. The prediction was made by noting from Ebro flocculi records the dates when ups and downs in solar activity seemed to begin and translating them backwards 2 days in each case to suit heat observations. I then wrote down in several successive columns the marches of temperature each of these solar changes portended. By adding the values in these several successive columns, the total expected temperature effect of all these solar changes was summed up. These results are plotted in the dotted line of

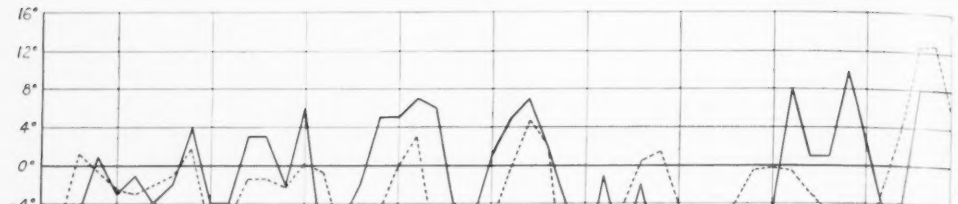


FIG. 2. PREDICTION OF TEMPERATURE DEPARTURES IN WASHINGTON, D. C. THE DOTTED LINE REPRESENTS TEMPERATURES PREDICTED FOR TEN DAYS IN ADVANCE FROM SOLAR CHANGES. THE SOLID LINE SHOWS THE TEMPERATURES THAT WERE ACTUALLY OBSERVED IN 1935.

Figure 2. It will be seen that the average difference between predicted and observed daily temperatures in this test prediction was but 4.9° F., and that the ups and downs of predicted and observed curves occurred nearly always on the same day. The actually observed range, as expected, exceeded the predicted range, for terrestrial influences were excluded from this purely solar prediction. Ordinary predictions for only 24 hours in advance are seldom more successful, either as regards the times of changes of temperature or the magnitudes of changes, than this long-range solar forecast.

I have predicted similarly for several other intervals. A summary of results is given in Table 1. On the whole I believe the method gives great promise. It can probably be improved in the hands of meteorologists skilled in knowledge of terrestrial influences. It can also be improved by combining all the evidence available from Smithsonian, Carnegie, and Ebro sources, so as to

TABLE 1

GENERAL SUMMARY OF A PURELY SOLAR PREDICTION OF THE DEPARTURES FROM NORMAL TEMPERATURE AT WASHINGTON, COVERING THE MONTHS MARCH AND APRIL OF 1911 AND 1915, AND SEPTEMBER AND OCTOBER OF 1917 AND 1935

Total days predicted		201	
Observed and predicted of same signs		139	
" " " " opposite signs		62	
Observed departures plus		65	
Predicted " "		64	
Observed departures minus		136	
Predicted " "		137	
			Percentages
Differences, Obs.-Pred.	0° to 2°	66	32.7
" " "	3° to 4°	43	21.3
" " "	5° to 6°	32	15.8
" " "	7° to 10°	33	16.3
" " "	11° to 15°	20	10.0
" " " greater than 15°		8	4.0
" " " less than 6°			69.8
" " " more than 6°			30.3
" " " , general mean			5°.35
Correlation coefficient 56.9 ± 3.2 percent.			

yield all the dates when solar changes appear to have occurred in the years from 1910 to 1944. For then the basic curves for any desired station will rest on many times more cases than those combined in the Smithsonian curves alone.

If the method comes to be officially used and is based on ionization measures, the combined results of some half-dozen observatories will be available. Combining these will eliminate spurious apparent dates of solar changes and will thus promote accuracy of prediction. I greatly hope that in this way excellent temperature forecasts for 10 days in advance may soon be made possible for many stations in the world.

Is this method also available for barometric pressure and precipitation? I have already made some studies of solar changes as related to barometric pressure and find the relationships are, as might be supposed, not so close as in the case of temperature. However, it seems that forecasts of barometric pressure may be of considerable value. As regards precipitation, the prospect for 10-day predictions is more doubtful. A combination of forecasts of temperature and barometric pressure might indeed give some grounds for a prediction of precipitation, but I should hardly anticipate a high average of success. Doubtless it will be found, when more extensive studies have gone forward, that the solar influence is more potent at some stations than at others. Some stations, indeed, may be found to be so strongly influenced by unpredictable terrestrial influences, that solar predictions at these stations will have little value.

Monthly averages of solar constant measurements, while apparently fluctuating in a perfectly haphazard way, really follow the pattern produced by the combination of 16 regular periods of different lengths, operating simultaneously. These periods, ranging from 8½ to 273 months, are all close to being integral fractions of 273 months, which, besides, is close to being double the length of the famous sunspot cycle of 11⅛ years. If these periodic solar changes are of importance in weather, we should therefore expect that the principal details of weather changes, reckoned as "departures from the normal," would tend to repeat themselves at intervals of nearly 23 years. For at the conclusion of this master period all the solar changes would begin to repeat in approximately the same order as at its beginning. There are one or two reservations I have made to this statement in my more technical publications, but by and large it is true.

I have in my office the records of departures from the normals in temperature and precipitation for many stations in all parts of the world, arranged in cycles of 23 years. As the monthly values jump about too much to display plainly what one wishes to look for, I have used 5-month smoothed running means of the monthly values of departures. Thus for Washington in 1944 the monthly departures from normal temperature in the months January to May were as follows:

Jan.	Feb.	Mar.	Apr.	May
+4.0	+2.8	+0.4	+0.5	+7.9

Their algebraic sum is +15.6°. Dividing by 5, I get, as the 5-month smoothed running mean for March 1944, the departure −3.3°. Similar procedure is followed for all other months.

When I compare the smoothed departures in successive cycles of 23 years each, I find for many stations a considerable similarity of principal features. I have reduced this circumstance to a rough-and-ready rule-of-thumb method of forecasting. I use it for months and even years in advance. My rule is this: As the master cycle is a little less than 23 years, I add alge-

braically the smoothed departure from normal of April, 46 years ago, to that of February, 23 years ago. Dividing by 2, I use the algebraic half as the departure for January this year, and so on for other months. I will give two illustrations of the degree of success sometimes attained by this rough method of forecasting.

Several years ago an army engineer, in charge of some work in the Tennessee Valley Authority, asked me to predict for him the percentage of normal precipitation to be expected in that area for the 3 months, November, December, and January. I warned him not to depend on my forecast too much, chose 10 stations to represent the area, and gave him for each one the forecasted precipitation according to the method above described. The average result for the 10 stations seemed to indicate between 84 and 87 percent of normal for the total precipitation of the 3 months. In February he informed me that it actually turned out to be 87 percent.

From 1934 to 1940 I had a letter each winter from a farmer in South Dakota, living about 100 miles from Bismarck. In 1934 he drew a dark picture of the great drought and begged me to tell him what the prospects were. I based my replies on what had happened at Bismarck 46 years earlier. I have found that for precipitation there is apt to be a greater similarity of events at intervals of 2 and 4 times the 23-year master cycle than in the 23-year intervals themselves. Unfortunately records 92 years back are seldom available. I myself was really astonished, however, by the approximate accuracy with which I forecasted each year the precipitation for the year to follow in the Bismarck region. After 6 years of this, my correspondent wrote in 1940: "For several years you have given us very accurate predictions of the season's weather, so accurate that I am constrained to solicit from you like guidance this year in the crops we may expect. I have great faith in your predictions."

While this is very flattering, I must discourage other similar inquirers. The fact is that it does not turn out so perfectly as this for every region. More compelling still, I have much important work in hand. If many farmers in the United States should apply to me, as they would be sure to do, and if I consented to answer their inquiries, I could not satisfy their demands even by giving up all the work I hope to finish in my few remaining years.

There is a better, but far more onerous, method for long-range solar forecasting than this rough-and-ready procedure I have described. Each of the 16 periods, integrally related to 273 months, has a measurable effect on temperature and precipitation. In illustration I may say that I have followed the effect of the 8½-month solar period on temperature at Copenhagen, Vienna, and New Haven from 1800 up to 1940—140 years altogether. It appears that the sun must have varied perfectly regularly in this 8½-month period throughout all that long interval. For at these 3 stations there was produced by this 8½-month solar period average temperature ranges as follows: Copenhagen, 2.35°; Vienna, 2.02°; New Haven, 1.30°. Some of the other solar periods are even more effective. If, however, they were only on equality with the 8½-month period they could bring about a swing of more than 20° in temperature between dates when they all tended together to raise, and dates when they all tended together to depress the temperature.

For several stations I have computed the average effect of each of the solar periods separately, by analysis of long temperature and precipitation records. Having thus determined their several effects, and the times when they severally occur, I have added them algebra-

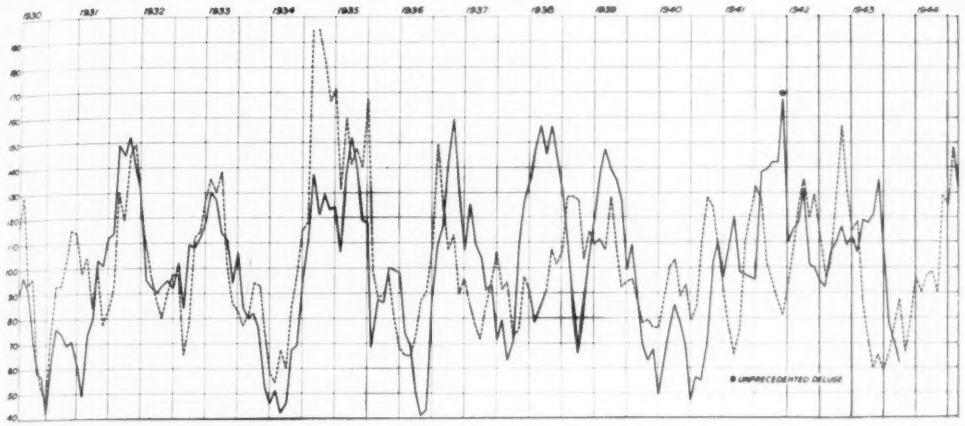


FIG. 3. PRECIPITATION AT PEORIA, ILL., 1930–1944

PREDICTED (DOTTED LINE) FOR FIFTEEN YEARS AND COMPARED WITH ACTUAL PRECIPITATION (SOLID LINE) DURING THAT PERIOD. THE VERTICAL SCALE GIVES PERCENTAGES OF NORMAL PRECIPITATION.

ically and have made predictions for years therefrom. One example is given in Figure 3. On the records of percentages of normal precipitation at Peoria, Ill., for every month from 1856 to 1929, inclusive, used as explained above in the form of 5-month running averages, I based a prediction for the years 1930 to 1944. In Figure 3 the solid line gives the actual event, as far as it was available when the graph was drawn. I feel pleased with the agreement between forecast and event for the years 1930 to 1937. A farmer who had the advantage of a forecast of this accuracy would know very well how to plan his crops. The general effect in 1938 and 1939 indeed is not bad, but in 1938 the features are not well predicted. The years 1939 and 1940 are again fairly satisfactory. Beyond that my prediction seems to get more and more in advance of the event, though both prediction and event show similar general trends upward from 1940 to 1942. It was doubtless too ambitious to make a forecast for 15 years in advance. One would have to be surer of the true lengths of the longer solar periods than our data can as yet show. If a new forecast had been started with 1940, putting forecast and event in coincidence then, possibly the succeeding 8 years might yield as good a fit between forecast and event as the years 1930 to 1937 did. I believe that these very long-range forecasts of temperature and precipitation from the periods of solar variation are well worth more investigation and in some localities will have great value. Such predictions, I regret to say, require many days of computation in each case.

In conclusion, I will draw attention to my earlier remark regarding the great depression of solar radiation in 1922, which was expected to recur in 1945, 23 years later. So very unusual an event in the fluctuations of solar radiation is sure to be accompanied by unusual conditions of weather. From a paper I wrote in 1923 regarding it I quote the following extracts from Weather Bureau statements:

> The record of December, 1922, shows unusual contrasts as to the temperature and precipitation in different parts of the country. . . .
>
> Like the preceding December, January 1923 was notable for the disturbed atmospheric conditions. . . .
>
> The outstanding feature of the weather . . . was the almost continuously high temperature . . . over much of the country. At the same

time, however, severe winter weather was the rule over New England and much of New York.

Precipitation occurred with unusual frequency . . . in northern districts west of the Continental Divide and from the Upper Lakes eastward. . . .

The disturbed atmospheric conditions, so persistent during the first two months of the present winter, continued into February. . . . The pressure distribution for the month as a whole showed marked variations from the conditions usually expected in February. . . .

The unseasonable warmth which had continued during most of the two preceding months of the winter save over the Northeastern States, terminated with the first few days of February, and the remainder of the month was distinctly cold. . . .

I wish I had had sufficient computing help to have analyzed and forecasted for various localities the weather implications of the solar situation expected to recur in 1945 and 1946, but I have been unable to do so. I must therefore content myself with a number of quotations that prove that already very unusual weather has occurred in various parts of the world.

By the United Press, Feb. 9, 1945: Eastern communities [of the United States] struggled from beneath new snowfalls today amid predictions of the worst floods in years on the seacoast and in the Mid West when the drifts begin to thaw.

At least two deaths were caused by the storm in New England, where transportation and communication was snarled. Boston streets were barely passable. Hundreds of war workers were stranded in Providence.

New York City suburbs had one of the heaviest snowfalls of the winter. Eight to 12 inches fell in eastern Massachusetts, Rhode Island, and Connecticut.

Along New England's coast northeast winds whistled at 55 to 65 miles an hour, reaching 75 in gusts.

Only light flurries hit northern and western New York State, where the railroads were winning their battle against snow and ice. Freight was rolling freely out of Buffalo.

Forecasters predicted an end to the storm today and a warm wave tomorrow that may thaw the deep snow and possibly flood ice-choked rivers throughout the Middle Atlantic area.

The Hudson was frozen to a depth of 24 inches in many stretches and the Chenango and Susquehanna rivers threatened trouble in a thaw.

New York City has a sea of slush. The city ordered 7,052 street workers on the job last night. LaGuardia Airport canceled 124 flights yesterday and reported that this winter has been the worst for flying since the terminal was built.

Disaster and relief agencies prepared for the worst flood year since 1936. The Coast Guard and Red Cross kept flood relief equipment ready for instant use.

Snows on the ground in the Ohio Valley, western Pennsylvania and the Connecticut River watershed are "much in excess" of the average for the last 20 years and snow coverage in the "feeder" areas of those districts also is "considerably more" than during the severe floods of 1936, William E. Hiatt, Mid West engineer for the Chicago Weather Bureau, reported.

Most serious threat was to Pittsburgh, where the Allegheny and Monongahela rivers converge to form the Ohio. The snowfall in that area has totaled 110 inches this winter with few thaws.

By the Associated Press: Canberra, Australia, Jan. 15, 1945. More than 2,000,000 wool-producing sheep have perished due to Australia's worst drought since being settled by whites and the country's most productive acres have been turned into huge dust-bowls. . . .

Meat production, it is estimated, will fall off 10 percent; the wheat farmers' income will be reduced by at least $50,000,000, and wool producers will lose an estimated $45,000,000. . . .

One of the gravest results will be that the United States forces in the Pacific will have to secure meat and flour from other sources, perhaps draining their home stocks.

Other such reports of weather conditions that have not been matched for a quarter of a century have appeared frequently in the press within the past two years. I look forward to making an extensive study in the immediate future of the variation of the sun and the changes of weather. I hope that results of a positive and easily verified nature may appear, so that a real contribution to meteorology may follow.

SCIENCE AND SOCIETY

By ERNEST CHERRINGTON, Jr.

THE abrupt conclusion of our war with Japan following closely the atomic blasting of Nagasaki has released a swirling torrent of opinion on the place of the scientist in society and his responsibilities thereto. A few critics have gone so far as to charge the atomic physicists with conspiracy to commit mass murder. Some men of science have retorted that it is not their responsibility that the greatest discovery of modern times has been adapted to purposes of destruction. It is scarcely surprising that such charges and countercharges should be hurled about during the present period of social confusion and intellectual hysteria. A stunned civilization gropes falteringly for means of escape from the fetid pit in which it finds itself after six years of unrestrained warfare. Scapegoats are quickly singled out in times like these, but a dispassionate analysis of the position against science finds it devoid of logic or justice. It is a question of how far indirect responsibility for death is to be traced, even in times of peace. Are the manufacturers of firearms guilty of murdering all who die by the gun? Are the hands of automobile designers stained with the blood of the 34,000 Americans killed each year by their machines? The victim of a traffic fatality is just as dead as the civilian blown to bits by a bomb dropped to destroy an enemy munitions plant, and the homicide is unintentional in both cases.

A less extreme point of view has been expressed by sociologist Joseph Schneider writing in THE SCIENTIFIC MONTHLY (November 1945). He holds that the unparalleled magnitude of destruction wrought by World War II is "of the scientist's own making." "There was a time," he continues, "when men of mind expressed only contempt for the vainglorious show of polities and war. But today the man of science has become a hireling, a willing subject in the service of the nation state; an indefatigable combatant in the righteous cause of a finite warrior god." It is implied that scientists have perpetrated a heinous crime against society to atone for which it now behooves them to get busy on useful discoveries and satisfy "the simplest needs of men." Professor Schneider is somewhat vague as to just whom he has charged with responsibility for creating the chaos under the accusation of being a scientist. If we adopt the broad definition of astronomer Harlow Shapley who writes that "we are nearly all scientists," then perhaps the indictment is general enough to include the guilty. The term "scientist" might be stretched to embrace those barons of international commerce who have fattened on the exploitation of colonial peoples and the control of raw materials, together with their colleagues, the politicians, who have created artificial trade barriers and have legalized a most inequitable distribution of the natural resources of the earth. In fixing the blame for the ravages of war let us not vent our wrath on the men who helped repel and defeat our attackers. Let us rather seek out those who caused the economic and social injustices that led to the slaughter.

Since to most of us the word scientist connotes an erudite individual concentrating on experiments in a secluded laboratory, let us now limit the term to include only those whose principal occupation is research or teaching in one of the branches of natural science.

The scientist too has raised his voice from time to time in regard to his position in the war effort. The declining Ph.D. rate of the past five years has been viewed with alarm, and the dire consequences of the present scarcity of technical specialists have been emphasized and re-emphasized. The induction of young scientists into the armed forces has been decried as shortsighted nationalistic planning. The implication has been that all those who enjoy the privilege of postgraduate scientific study are to become the future benefactors of mankind, and that they should, therefore, have been exempted from the draft. If the argument is valid, its application is broad. It should likewise have applied to those young men who were preparing for careers in education, literature, art, law, public administration, agriculture, industrial management—in short, any calling which in some way serves the needs of humanity. If it be granted that any one group of young men should be exempted from military service on grounds of exceptional value to society, the logical conclusion of such reasoning is that only the unintelligent and those who have been denied the opportunity of specialized education should be called upon to fight for our country in the hour of attack. In other words, those who are likely to benefit least from the American way of life should be detailed to defend it for the rest of us. Such a policy of selective service would be not only the antithesis of the democratic principle; it would be suicidal as a means of national security.

A great many scientists of varying ages and degrees of proficiency have devoted the past few years to war research under the direction of the Office of Scientific Research and Development. Almost all of these men and women have undertaken such work with the sincere desire to aid their country to the best of their ability in its time of need. A few were lured from the paths of pure science by the enticement of higher salary, and a few hurried into war research with the local draft board in close pursuit. But regardless of which entrance they used, once inside they have worked hard and have done a splendid job. Had the scientists of America resolved to hold themselves aloof from the revolting butchery of modern warfare, a course of action indicated by Professor Schneider as appropriate for "men of mind," one can only guess how many years longer World War II would have dragged on and how many hundreds of thousands of additional American lives it would have consumed. In that eventuality, how would the scientist's crime of omission have compared with his present alleged crime of commission?

The overwhelming majority of professional men have served our nation during the years of war emergency either as civilians or as members of the armed forces with no more complaint than is heard from the average soldier regarding his lot. However, attention to war research at the expense of the normal pursuit of pure science has been to a few scientists a cross they have borne noisily. Several articles have appeared in recent months lamenting the wasted years of brilliant specialists forced to develop military gadgets when they might have used their time and talent to discover new principles in the realm of abstract investigation. The situation is indeed regrettable, but, after all, who has not found his life and his purpose adversely affected by the war?

The scientist has usually been well-paid for his military investigations. He has usually worked in comfortable laboratories where every facility has been provided. He has usually been able to spend his spare time each day in the company of his family. Consider by comparison the young men of the armed forces snatched from their homes, torn

from new enterprises well begun, and shipped overseas to fight, to suffer, and often to die in a hideous maelstrom of destruction, separated by thousands of miles and years of time from their loved ones. Has the scientist been asked to make too great a sacrifice at a time when our nation faced disaster? Even one of the exponents of the "wasted-years" hypothesis grudgingly concedes that not quite all the work in the laboratory during the past five years has been fundamentally useless. Physicist I. I. Rabi, writing in the *Atlantic Monthly,* admits that "our advance in pure science, when we get back to it, may be greatly accelerated by the use of new techniques developed during the war, if," he adds gloomily, "those whose business it is to supply the funds will stand the expense and not insist upon calling the tune."

When the heat has gone out of the argument, and the smoke of the salvos has drifted away, probably it will be agreed that the role of the scientist in World War II has made of him neither a criminal nor a martyr. He had a job to do and he did it well. Never before in its history has science mustered so large an army of research experts dedicated to the satisfaction of the immediate, practical need of humanity. Radar, the variable timing fuse, the terrible atomic bomb, and thousands of other less spectacular devices were developed by our scientists and used with great effect by our armed forces to drive back and defeat a treacherous, fanatical, and inhuman enemy whose sworn purpose was the obliteration of the democratic way of life. With such a magnificent record of service to humanity just completed, why is it that certain intellectual and spiritual leaders rise to denounce the scientist in bitter terms? Why, also, do some men of science feel that they have wasted their time? Is humanity ungrateful toward those who have contributed so liberally to her salvation? Do the latter question the value of saving the former? Such questions lead us below the surface issues to an unwholesome situation that has developed gradually over a long period of time. The sensational and violent events of World War II have not created the condition but only accentuated it. The fact of the matter is that there exists today a broad chasm between the professional scientist on the one hand and his fellow-men on the other. Long before the war began this chasm had widened to the stage of misunderstanding. During the chaotic years of war its jagged edges have receded to embrace both distrust and fear.

Just as the Grand Canyon of the Colorado River may be traced upstream to a small crevice high in the Rocky Mountains, the present yawning abyss between science and society may be traced back through years of progress to a tiny fissure. That fissure is marked by the concept of atomic structure. So long as the atom remained but an infinitesimal billiard ball, chemistry, physics, and astronomy were studies any intelligent person could explore thoroughly and understand with a reasonable amount of intellectual effort, either as a student in the classroom or as an amateur scholar in his hours of leisure. The entire accumulation of knowledge could be treated adequately in a small volume for each subject. Scientists had time to write such books, and laymen had time to read them. With the breakdown of the atom, the scientist parted company with his fellow-men. Since then he has pursued a lonely course farther and farther into the realm of abstraction on the other side of the widening canyon. His life has become so filled with technicalities that he has scarcely had time to be a human being. The paths of investigation opened up have been limitless, and an ever increasing number of technicians have joined the chase, each pressing on

breathlessly lest his colleagues beat him to the nebulous treasures of knowledge that lie somewhere ahead. Each has had to devote six, eight, or more years of his life to intensive specialized study in order to skim over the important discoveries and the endless minutiae which have already been added to the total of information in his special branch of a general division of the science he has chosen. Having at last reached the frontier, he plunges into the underbrush and loses thereafter all contact with society.

ALMOST every intelligent, civilized person has an inherent interest in things scientific. This desire for knowledge of how things work has brought him again and again to the scientist requesting instruction. It had become all too common in the years preceding the war for the scientist rudely to brush aside such requests with the excuse that he was too busy to explain the matter or that the subject was too technical to be understood by the nonspecialist. Thus science has turned away from mankind and has forged upward, building a vast Tower of Babel in the shape of an inverted pyramid, the main entrance of which was marked years ago with a conspicuous sign "For Members Only." From its small foundation consisting of the subatomic concept, the strange structure has towered aloft into the clouds themselves, from which its high priests have recently cast down the thunderbolt of subatomic energy. Is it surprising, then, that intelligent members of society, forced to remain in ignorance of what has gone on in the awful temple of science, have risen to demand that the scientist give an accounting of what he has done and of what he proposes to do about the terrible forces he has unleashed?

Some will assert that this picture is unfair. Reference will be made to the books, the magazine articles, and the popular lectures on scientific subjects that have been presented continuously and in large numbers during the years of peace. True, there has been considerable popularization of science, but who has performed it and of what has it consisted? In answer to the first question, it will be found that almost all of the material released for public consumption has been prepared by interpreters who belong to one of two groups: first, the outstanding scientists who fully recognize their responsibility to society; and, second, the science news writers, whose profession it is to storm the walls of the citadel and bring out to the public descriptions of what they have seen inside. As to the content of the reports to the layman, a great deal of it has been old, pre-atom stuff. The intelligent nonspecialist has been patronized and given only what it was thought he could understand. Let the skeptical reader ask himself how many scientists of his own acquaintance devote even a small portion of their time to reporting the progress of their current research to their fellow-men.

Most of the leaders of science today are doing their best to remedy this evil, but unfortunately their number is small compared with the rank and file of professional scientists. Far too many of the latter live out their lives at public expense and contribute little or nothing to the welfare or intellectual development of society. These individuals recognize, perhaps unconsciously, that they are little better than parasites on the human race and, refusing to admit the fact even to themselves, they subconsciously set up a defense mechanism consisting of an attitude of superiority. As intellectual snobs they retire permanently to ivory laboratories and observatories where they continue their investigations of minutiae, emerging only occasionally to flay for their nig-

gardliness those on whose gratuities they exist. Of course they report the results of their research, but all their papers are written in equations and technical jargon. They publish exclusively in professional journals, which reach only their fellow-specialists and the shelves of the larger libraries. It often happens that much of such a publication consists of material previously printed in foreign journals or even more obscure periodicals—old data regrouped and rehashed with just enough new measurements added to change the conclusions of the original writer. Among these gentlemen of the self-appointed intellectual hierarchy there are two schools of thought as to what constitutes the highest evidence of scholarship. One contends that it is the number of titles on his list of published papers while the other argues that it is the total number of printed pages that really counts.

Let it be reiterated that the above description is not intended to be a caricature of all scientists or even of the typical scientist. Nevertheless it applies to an important minority of the class—important not so much for their number as for the damage the cause of science suffers at their hands. It was perhaps not Confucius who said that one dead horse may command greater public attention than thirteen live ones, but the illustration is apropos.

It has never been the custom of society to support a privileged class of individuals from which it receives little or nothing in return when that galling course of action could be avoided. During the past two centuries the people of the civilized nations have eliminated one such class after another. Does the professional scientist face the possibility of a similar fate as a result of the antisocial attitude of a group of his colleagues? Perhaps not, but the seriousness of the situation merits the deep concern of the more responsible members of the profession. "If those whose business it is to furnish the funds will stand the expense and not insist upon calling the tune"—that phrase frankly expresses the feeling of many scientists toward their patrons. Why is it someone's business to furnish the funds regardless of value received? We live today in a hard, business world, and if the man on the street ceases to produce either articles or services that society can use, he soon finds himself without income. Why should the scientist be an exception to this rule? Spoiled by the apparently limitless funds the federal government poured out for war research, many scientists will return to their former positions with demands for new facilities far in excess of any they dared hope for in years before the war. Research foundations both large and small will probably call upon their sponsors for increased appropriations at a time when the enthusiasm of society for scientific investigation seems to have reached its lowest ebb. The outcome looks rather obvious unless the scientist takes steps at once to regain the respect and confidence of his fellow-men.

Professor Rabi argues vigorously that science can advance only when research is carried out on a high plane of pure theory and experimentation with no thought of deriving results of practical value to humanity. One certainly need not search far to find numerous outstanding contradictions to such a view. Was not the foundation of chemistry laid by the ancient alchemists whose motives were the highly practical ones of making gold from cheaper metals and of discovering the elixir of life? A number of the fundamental laws of astronomy were discovered by medieval observers who were seeking astrological relationships which they thought would enable them to forecast the future—a most practical, if futile, purpose. Even today the pure-motive hypothesis is

questionable. An analysis of the current technical literature of chemistry and physics will show that a great many important principles and fundamental relationships have been discovered by scientists working in industrial laboratories who began with general practical ends in mind and who climaxed their investigations with the development of new and valuable industrial materials and commercial devices. It is certainly not my contention that scientists must invent practical gadgets in order to benefit mankind. The point to be made is that science should be able to live and flourish outside the artificial atmosphere of unlimited financial resources and unlimited social irresponsibility. If genius is so nearly dead that it can exist only in an oxygen tent, we can scarcely expect to postpone the funeral much longer.

There are two ways in which the professional scientist can serve humanity. The first method is by the development of "better things for better living." The second method is by contributing to the education of society as a whole in order that the lives of men may be enriched through understanding of an appreciation for the physical universe and all it contains—from stellar galaxies down to subatomic configurations. Path number one, the focus of the present controversy, has been discussed sufficiently. The second path may be pursued either by enthusiastic teaching in an educational institution or by popular writing and public lecturing on current research. The scientist who refuses to follow one or the other course of action is unworthy of his salt.

It is time that each man of science sat down at his desk and examined the book of his account with society. The debit side of the ledger will be crowded with entries. There he will find everything he knows—the entire cost of his general and specialized education—all he has learned from the experience of the past and everything he has discovered in his own investigations. There he will also find his position in the community, his home, every comfort he enjoys, everything he owns, and every facility to which he has access. But what about the credit side of the ledger? If a teacher, does he make an honest effort to disseminate effectively his knowledge among his fellow-men, or does he regard teaching as an odious task necessary to secure his pay check? Does he report his researches to the public in understandable language, or does he write exclusively for technical journals of small circulation and lecture only before meetings of his professional society? Does he graciously admit interested laymen to his place of research, or does he keep the door locked in order not to be bothered? Does he try to explain what goes on at the frontier of his science, or does he save himself the trouble by assuming that the average man is too stupid to understand such matters? Does he improvise and use to the utmost the research facilities available to him, or does he sulk in inactivity complaining that his apparatus is antiquated and useless? When he needs new equipment does he go out and really sell his program, or does he curtly demand that "those whose business it is to supply the funds" do their duty? Is his research enlightening and inspiring, or has it degenerated into the humdrum process of assembling, sorting, and cataloguing minutiae?

It is through frank answers to questions such as these that the scientist may trace the origin of the storm of public criticism that swirls about his laboratory today. Let him heed well the fact that the storm is of his own brewing. Let him revise his program better to meet the needs of the postwar world. Let him do so at once before a disillusioned society decides the matter for him and again demands that science take a holiday—this time a long one.

THE STRANGE TRINITY CALLED MAN

By A. BOYAJIAN

THAT human nature is a highly complex mixture of good and bad is a very old story, but that it is a trinity—a genuine three-persons-in-one trinity—is a discovery of psychoanalysis.

The fundamental difference between conventional psychology and psychoanalysis is this: while the former has always concerned itself with the consciousness, the latter has recognized that human personality is like an iceberg. A small portion of it is exposed to view above the surface, in the conscious mind; the bulk of it is concealed from view below the surface, in the subconscious, or in the depths of the unconscious. All strange behavior, even insane behavior, becomes explicable when its motivation is traced into these lower levels. The differentiation of the three partners in the trinity is visible enough above the surface of consciousness after it is pointed out, but it is particularly conspicuous at levels below the surface of the consciousness when these depths are probed by psychoanalytic methods.

The so-called "unconscious" is not unconscious by any means; it is not a blind machine. It knows full well what it wants, and makes plans for it sometimes more shrewdly than the conscious mind: it is unconscious only in the sense that our waking consciousness is not directly aware of all that goes on in it.

The popular misconception of psychoanalysis as the psychology of sex originates in the fact that sex may play a more conspicuous role in the unconscious than in the conscious mind, and therefore it occupies a more prominent place in the psychoanalytic literature. The primary object of study of psychoanalysis, however, is the unconscious—the study of sex is only incidental.

When the three persons of the trinity function harmoniously, they may appear as different faculties or tendencies of the same person, and the casual observer may dismiss the theory of three persons in one as pedantry. However, when the three begin to work at cross-purposes, especially when discord breaks out among them so that one persecutes another, or worse yet, when one murders another (incidentally killing all three), there cannot be much doubt left as to whether human personality is more significantly interpreted as a trinity or merely as one person having a number of faculties and tendencies.

That there has been some recognition of multiplicity in human nature is not to be denied. Who has not heard of the "body-mind-and-soul" theory of man? More often, however, human nature has been pronounced duplex. St. Paul was emphatic on the distinction between the "carnal" and the "spiritual" man. The "Dr.-Jekyll-and-Mr.-Hyde" picture is classic. While these contain much truth, they are very inadequate. They are not only fragmentary but also unscientific in conception and erroneous in some of their important implications. For this very reason, it has been necessary to give new names to the three persons distinguished by psychoanalysis, so as to avoid the notions that cling to old words.

Let us identify the three personalities briefly and then review some of their famous conflicts in history and fiction.

First comes the *Ego*, a well-enough known fellow. He is the personification of reason, and the nominal head and mouthpiece of the trinity. As such, he generally poses and passes for the whole personality. Our "company manners"

are largely those of the Ego. His major attributes are common sense, prudence, and expedience. In some respects, the Ego is the most decent member of the trinity, but he is also the weakest and is easily corrupted by the others. He counsels his partners, furnishes them expert knowledge, and acts as their executive; but frequently the others fool him or simply compel him to carry out their dictates against his own better judgment. He writes scientific treatises, develops philosophical systems, makes inventions, and in matters of abstract truth, such as mathematics, he talks with an absolute authority as if he were the voice of God. And yet, the amount of stupidity the Ego has advocated through the centuries is simply astounding. And in spite of all his talents, the Ego plays only a minor role in art and religion.

The psychoanalytic name of the second member of the trinity is *Id.* This name may sound Chinese, but the Id is *us* more intimately than the other two members of the trinity, and far more important than they because he represents the *life instincts,* or *vital drives,* in us. Although these instincts, or drives, are many, they are so well united in the long evolutionary process that in the normal person they do not ordinarily exhibit cleavage into separate personalities. The Id likes sex and is libidinous, but he is so only because he is the source of all emotion, and hence of love in all its manifestations, and also of much hate.

The Id is the creative member of the trinity. He surely is more than animal, as he is the fountainhead of all artistic inspiration. The Ego can write verse, but only the Id can put into it the spirit that elevates verse to the rank of poetry. The Ego can furnish correct harmony (after learning it from the Id), but only the Id can furnish an enduring melody. The Ego can draw and color, but only the Id can furnish the ingredient that makes the difference between a colored drawing and an artistic painting. The Ego can write excellent history, but only the Id can write good fiction. Our gentlest emotions spring from the Id; and the tender grace of parenthood is his exclusive gift. The Ego strains his intellect and calls God "the Infinite," which means "bigger than you can imagine"—a sorry compliment. Intuitively, the Id calls him "Father" and infuses human life with divinity.

The Ego's workshop is in the cortex, that of the Id extends down to the thalamus, and therefore much of the latter's activity is below the surface of consciousness. Thus, when communications reach the Ego from the Id, they may appear as sudden inspirations.

In the unconscious, the Id preoccupies himself particularly with those interests of his that are repressed by the other members of the trinity. Sex is perhaps the most important one of those interests, but there are others, many of them arising from infantile and childhood experiences. The manifestations of the subconscious workings of sexual energy so impressed Freud that he christened them the Libido. So, in the early days of the new science, the human personality was double (even though not officially so stated)—the Ego and the Libido. Some psychoanalysts now use the word Libido more broadly as synonymous with Id. In this article it will be so used because it is a more familiar word, with more color and potential—although a certain amount of odium also attaches to it, from which the colorless word Id is free.

The Id, or Libido, is the dynamo of the trinity: he furnishes both objectives and energy to the Ego; he is perpetually bent on achieving some desired goal and would destroy anything that stands in his way, except for the restraining hands of the other two persons of the trinity—the rational Ego and the third person.

And who is this third person?

Conscience is his popular name, *Super-*

ego his psychoanalytic name. That conscience speaks to us as if it were the voice of another person—perhaps as the voice of God—will be readily granted, and to that extent at least, the multiplicity of human personality may be conceded. The fundamental difference between the psychoanalytic concept of the Superego and the popular notion of conscience is that the Superego is larger than the conscience and includes it. Conscience is the Superego as the latter appears in consciousness, but the Superego works also in the unconscious, as the *conscience of the unconscious*, and does some of its most important work there. Of the latter, we are not directly aware, but we have a great deal of indirect positive knowledge of it.

Conscience is sometimes thought of as primarily interested in religion, but the Superego is seen to enforce all tribal and social taboos, political loyalties, the dictates of fashion, the codes of professional conduct, the amenities of the club, the rules of the shop, the rules of sport, the traffic regulations, and even the unwritten codes of the gangsters. At the subconscious level, it keeps guard over the Libido and the bodily functions, even when the Ego sleeps. For instance, it guards the sphincter muscle to keep the bedding dry and clean; keeps dreams within bounds; and wakes us up in the morning at the right time.

Censorship of the Libido is, of course, also one of the functions of the Ego. Perhaps because routine repetitive censorship would be an unnecessary burden on the Ego, this duty has evolved into a separate function delegated to the Superego. As this type of work does not require much intelligence, the Superego is a dullard compared with his partners. He is easily won over by all kinds of established authority and is *the great ally of conservatism*, although he also spurs an occasional crusader. The very fact that it is the function of the Superego to *check* the Libido carries with it the danger that a hypertrophied, or otherwise malfunctioning Superego, may tend to *choke* the Libido.

Human personality, then, consists of these three persons: Ego, Superego, and Libido; or, in the more familiar terms, Reason, Conscience, and Desire. In the normal individual, they so complement and balance each other that the resultant is an apparently single personality with a certain characteristic complexion, depending on their proportionate strength.

Under the influence of alcohol, the equilibrium within the personalities of our trinity is altered, and hence the complexion of our composite personality changes. The Ego and Superego are dulled more than the Libido, and therefore the latter gets freer rein. Thus his joy in living and loving comes to the fore more conspicuously. While it is generally recognized that alcohol "releases tensions," it is not so generally understood that these "tensions" are conflicts within the trinity and are eased by dulling the *censorious* partners and "releasing" the Libido.

At night the Ego sleeps much more deeply than the other two, and the complexion of our sleeping personality is considerably different from that of our waking one. This shows itself clearly in dreams. The Libido takes advantage of the drowsy Ego and enacts its hopes, wishes, and fears in dramatic scenes on the stage of the lower levels of consciousness. The Ego takes these dreams as reality because he knows he is not imagining them and, being drowsy, he does not suspect that the Libido may be concocting them. In every dream there are three real persons, namely, the partners in the trinity. All others are puppets, mostly the creations of the Libido. Concealed in the subconscious, the Libido pulls the strings and speaks for the puppets as a master-ventriloquist. The Ego watches as an innocent bystander or fre-

quently enters into the play, like a spectator walking up to a magician's platform. As the Libido is rigidly controlled during waking hours, now it would like to do a lot of wishful thinking without arousing its censorious partners. To accomplish this, it resorts to symbolism, and that makes dreams seem fantastic; but dreams are no more so than code messages. When decoded, both make sense, sometimes fearful sense. Thus, dreams provide a clue as to what is going on in the subconscious, and that is why the psychoanalyst is very much interested in them. Many a symbolic murder is committed by the Libido in dreams, without the knowledge of the Ego or the Superego. The person remembers the dream but does not understand it and may not believe the interpretation of the psychoanalyst. Conflicts in the unconscious, between the Superego and the Libido, lead to symbolic nightmares, although we may well grant a nightmare may also be caused by a physiological discomfort. Even in the latter case, it is possible that the physiological discomfort initiates the mental conflict.

The Libido uses skillful camouflage to dodge the censorship of the Ego and Superego, even in our waking hours. At the New York World's Fair, millions of men and women innocently gazed at and admired the "theme" of the Fair—the Trylon and Perisphere—while their unconscious drank in the lightly disguised phallic symbolism. We may grant that the architect's Ego also was innocent in this matter. He says the Trylon was the logical answer to the requirement of visibility, and the Perisphere was needed for an interior display of the nighttime view of the heavens and the countryside. How clever of the Libido, and how naive and innocent of the Ego! The architect never explained why the Trylon and the Perisphere had to be adjacent to each other; what need there was for such deceptive words as Trylon and Perisphere; and why no elevator was ever placed in the Trylon to enable visitors to get an adequate view of the Fair. Artists put things in their paintings unaware, and it is common knowledge that composers do not always understand the music welling up from the unconscious. So they call their compositions "Symphony No. 1," "Concerto No. 2," etc. It was some time after the composition of his *Fifth Symphony* that Beethoven interpreted it as "Thus Fate Knocks at the Door." In daily life, much of our motivation is unconscious—from either the Libido or the Superego—and our "reasons" for our behavior frequently are only rationalizations.

The Superego not only restrains but may also punish. "He that diggeth a pit shall fall into it," says the Good Book, and centuries of human experience show that it is true. Who or what could be the agency for such divine justice? Why look beyond the Superego? While the Libido and the Ego have turned a deaf ear to him and are digging a pit for the innocent, the Superego is muttering, "Wait and see if I don't push you two into that pit when you're unwary."

Just as Reason's function is to be an unerring guide to truth (though he is frequently guilty of much stupidity), so Conscience's function is to be an unerring guide to ideal conduct (though he is frequently guilty of much crime). Often, too, he is neither the voice of God nor of reason but of some tradition, prejudice, or some other false authority. Right or wrong, he acts as judge, jury, and executioner and punishes disobedience, sometimes with much cruelty. He is impartial, too, punishing his partners sometimes worse than others. The horrors of the inquisitions perpetrated by cruel Superegoes are well known. Witness the following letter written by the minister of a Boston church in the year of our Lord 1682:

TO YE AGED AND BELOVED, MR. JOHN HIGGINSON:

There be now at sea a ship called Welcome, which has on board 100 or more of the heretics and malignants called Quakers, with W. Penn, who is the chief scamp, at the head of them. The General Court has accordingly given sacred orders to Master Malachi Huscott, of the brig Porpoise, to waylay the said Welcome slyly as near the Cape of Cod as may be, and make captive the said Penn and his ungodly crew, so that the Lord may be glorified and not mocked on the soil of this new country with the heathen worship of these people. Much spoil can be made of selling the whole lot to Barbadoes, where slaves fetch good prices in rum and sugar, and we shall not only do the Lord great good by punishing the wickeds, but we shall make great good for His Minister.

Yours in the bowels of Christ,

COTTON MATHER

If such a Superego should turn against its partners, would it hesitate at killing them "so that the Lord may be glorified"? The ascetic self-tortures of the early centuries represent a cruel Superego torturing the Libido with the assent of a mistaken Ego, based on a misunderstanding of the gospel of Jesus Christ. Such asceticism is nearly extinct now, but other forms of masochism are in style.

Let us consider now some classical cases of murderous conflict within this unholy trinity. For the purposes of this article we shall define as *true suicide* only those cases of self-destruction in which the three persons of the trinity agree that death is better than life, but as *murder* those cases resulting from a conflict among them. Sometimes we can tell which of the trinity killed which, with malice aforethought, with full knowledge that killing the other will be the end of all three, and reconciled to it: a suicidal murder, but murder just the same. Although the end effect is the same in both cases—death for the trinity—yet in the first case the motive is suicide, in the second, murder.

It is a surprising conclusion of some psychoanalysts that true suicides are rare. Frequently, what appears as a suicide in the coroner's report is murder within the trinity. For instance:

In Victor Hugo's immortal novel, *Les Misérables*, we see the police officer Javert standing on the brink of the river Seine in Paris, in the dead of the night. He plunges in and is drowned.

Suicide or murder?

Murder of an implacable Superego by a Libido and Ego in desperation. Javert's conscience, as the agent of the law, was making life miserable for Jean Valjean, with whom Javert's Ego and Libido sympathized and suffered and revolted. Death alone would silence that unreasonable conscience of his, so death was dealt to him.

That story features also conflict within the personality of the hero—Jean Valjean—his Superego hounding him all through the story, demanding surrender to the law with great humiliation to his Ego and great privation to his Id, and these two resisting the Superego successfully as long as no one else is concerned. But the moment the interests of another person are endangered, the Superego is aroused to greater effort and obtains the surrender of the other two. When Jean Valjean's son-in-law learned of his painful past (and present) and offered to secure pardon for him through political influence, he answered that what he needed was pardon from his conscience! But that could not be secured through political influence and was not secured even by all his good deeds, and so his whole life was one of agony and martyrdom to his conscience.

The story of Dr. Jekyll and Mr. Hyde ends with what the coroner would call suicide. The screen version recognized murder in it and ended with words like "Mr. Hyde has killed Dr. Jekyll." Undoubtedly, Hyde's scandalous conduct led to the tragic end, and therefore the Libido may be said to have killed the Ego. But what is lacking is explicit recognition of the trinity, of the part played by the Superego. In the long-drawn-out conflict between the Superego

and the Libido, the latter had the upper hand until the situation arose in which life's appeal to the Libido was greatly weakened. The Superego, now more infuriated than ever, ordered the Ego to kill and punish the Libido. The order was carried out because the Libido was now too indifferent to life to offer serious resistance.

A fourteen-year old apprentice of a cobbler was very much impressed by an adult conversation about a certain customer having been blinded for blasphemy. Soon after that, his eyes began to bother him, and an oculist advised him to change his occupation to something less exacting to the eyes. His eyes, however, steadily grew worse, and on occasions his retina would bleed. Oculists were unable to help, and the boy (by this time a man) consulted the psychiatrist Georg Groddeck, telling him his story. For brevity, the diagnosis and subsequent events are condensed here into a short dialogue.

Doctor. How do you account for the bleeding of your eyes?

Patient. It happens invariably in the fall, in October, and also at other irregular times. In the fall, nature is dying, and I feel sad. I cannot account for the other times, or the present case except that my little girl accidently hit me in the eye.

D. Did anything serious happen to you in the fall?

P. No.

D. Give me a number. Any number.

P. Eight.

D. Did anything serious happen to you when you were eight?

P. No.

(Previous reference to the blind man came to the doctor's mind.)

D. Did you ever blaspheme God?

P. (laughing.) I used to be a pious child but for many years I have not gone to church. I don't believe in those things any more.

Suddenly the man grew pale, and fainted away. When he came to himself again, he broke down in weeping confession.

P. Doctor, you are right. I am a blasphemer. It was in October, I was eight years old, and with a bunch of other boys, I was throwing stones at a border crucifix. My stone hit the mark, and the image of Christ fell down and broke into pieces. We fled, terrified.

D. When did this last bleeding start?

P. Yesterday, at five, while I was waiting for a car at a certain corner.

D. Go back there now, look all around, and report to me what you see.

The patient returned with a statement that he saw a large crucifix!

The retinal hemorrhage was punishment administered by an ill-advised superego, aroused by the sight of the crucifix. With the reeducation of the patient's mind, his eyes steadily improved, and in time he secured and held a job as a bookkeeper, a most severe task for eyes.

Consider St. Paul's case. His stern Superego, energetic Libido, and mistaken Ego conspired to persecute the Christians. He helped stone Stephen, and drove others into dark dungeons. He probably threatened also to blind them so they would be eternally in a dark dungeon. But as his contact with the Christians grew, his Ego saw that these were not bad people, that it was a crime to persecute them. The Superego then relented, but the Libido continued the persecution. On the way to Damascus, the Superego revolted against the Libido and turned on it with a terrific thrust: It's you that deserves to be blinded, not those Christians, and you're going to get it! The subconscious explosion sounded like thunder and lightning to his Ego. He was knocked down blind and helpless. "Saul, Saul, . . . it is hard for thee to kick against the goads [of thy conscience]." When Ananias gave him the authoritative word of forgiveness for his sin, Paul's Superego relented, and his Libido regained his sight.

The Master-Healer knew intuitively the need of many of his patients and applied the correct remedy to them, saying, though not to all, "Son, thy sins are forgiven thee." These people went home happy, not only because their physical ailments had been relieved, but also because they felt a joy and peace in their hearts transcending their understanding. The magic words of the Master had relieved the unconscious conflicts gnawing at their vitals.

The flowering of Christian love in

Paul's Libido never quite succeeded in completely humanizing his intolerant Conscience. Listen to him write to the Galatians, who have had a doctrinal row: "This simply means that certain individuals are unsettling you; they want to distort the Gospel of Christ. Now even though it were myself or some angel from heaven, whoever preaches a gospel that contradicts the gospel I preached to you, God's curse be on him! I have said it before and I now repeat it; God's curse be on him!" (Gal. 1:7–9) Compare this with the spirit of the Master: ". . . they went, and entered into a village of the Samaritans . . . and they [the Samaritans] did not receive him. . . . And when his disciples, James and John, saw this, they said, Lord, wilt thou that we command fire to come down from heaven, and consume them, even as Elias did? But he turned and rebuked them, and said, Ye know not what manner of spirit ye are of." (Luke 9:52–55).

Paul's theology also was profoundly influenced by his stern Superego. The following words of James probably represented also the temper of Paul's conscience: "For whoever shall keep the whole law, and yet stumble in one point, he is become guilty of all." (That is, if you pass a red traffic light, you thereby become guilty under all the provisions of the penal code.) Such a stern conscience could not be appeased with anything less than the most precious blood, and Paul had the inspiration to offer the blood of Jesus Christ in his defense. That was one of the most momentous events in history—for ages to come, humanity suffering at heart as Paul did will find salvation and joy as he did.

Like astronomy, psychoanalysis is neither religious nor irreligious: it only reveals the mechanism through which man, God, or the Devil may work. As an example of the Devil's work, the Ammonites sacrificed their first-born to Moloch. Whom were they appeasing? A stone statue? More likely, the Moloch of a Superego in their unconscious. Superstition? Of course, but that only because in all ages people have fashioned their gods in their own image. The Hebrews solved the conflict in the human personality by a token sacrifice of sex in the ritual of circumcision, supplemented by the shedding of the blood of an animal.

Although generally the conflict is between the Superego and the Libido, sometimes it is between the Superego and the Ego. Here is an example that recently appeared in the papers:

MINISTER'S SON KILLS SELF

A minister's 16-year-old son, who left notes indicating that he debated with himself questions of belief and nonbelief, was found dead in a L———— College chemical laboratory today. Sixteen gas jets in the room located in Gayley Hall were open, according to police, who said a note had been fastened to the laboratory door, warning other students against entering because of the fumes. The boy was J———— B. R————, 16, a freshman, whose father is the Rev. M———— R————, pastor of C———— Presbyterian Church, Staten Island, N. Y. R———— was on the dean's list and was a member of the college choir.

Although death from conflict between theological dogma and reason are unusual, milder cases of such conflict are quite common among scientific people brought up in fundamentalist families. A *modus vivendi* is generally established by going to church on Sunday, to the laboratory on Monday, and by never discussing doctrinal matters or even religion.

Violently murderous conflict within the human personality is of course rare, but a greater amount of harm is done by the less spectacular cases because they are so prevalent.

An oversimplified picture of the development of an internal conflict between the Superego and the Libido in the adult may be described as follows: An antagonistic social environment, more powerful than the individual, arouses aggressive impulses in the Id, and these are repressed jointly by the Ego and the

Superego, the former counseling prudence, the latter demanding obedience to authority. The repressed resentment festers in the subconscious into more seriously aggressive impulses, and this excites the Superego into more drastic controls against the Id. Thus, tension begins to build up and may explode sometime. Surely, "Blessed are the meek." Blessed are also those who are not exactly meek but have mastered the art of diverting into constructive activities those pugnacious energies that may be mobilized in them by external opposition.

Human unhappiness arising from internal conflict is deeper than that from external conflict, though the two react on each other; and the establishment of internal peace may be a prerequisite to the establishment of a durable world peace. If we could but see the internal conflicts of men like Hitler engaged in creating a world conflict! About the general causes of war, perhaps the ostensible ones, like the Versailles Treaty, etc., are merely excuses, the real causes being the conflicts within the personalities of the leaders. James said many centuries ago: "Whence come wars and whence come fightings among you? Come they not hence, even of your passions, that war in your members?"

In *The Art of Happiness,* John Cowper Powys says:

> I myself have discovered, from examining the behavior of my own mind, that there is a cruel demon in it that derives sadistic pleasure from trying to force me to think of the very things that especially make me shudder. And the happier I feel, . . . , the more energetically does this demon under my own helmet call to my attention what I particularly loathe to think about.

That there is in all of us a will-to-life is universally recognized, and self-preservation is said to be the first law of nature. Some philosophers have also observed that in all of us there is also a will-to-death, as if self-destruction might be a second law of nature. This is stated very effectively by Dorothea Brande in *Wake Up and Live:* "With the time and energy we spend in making failure a certainty, we might have certain success. . . . *It takes energy to fail.* . . . Then why do we *work hard* at failure? Because, besides being creatures subject to the Will-to-Live and the Will-to-Power, we are driven by another will, the Will-to-Fail, or Die."

This condition may be responsible for certain slow, unconscious suicides, producing either organic or functional disorders. People who do not spare themselves, those who take unnecessary chances, may well be suspected as ailing with a mild case of will-to-death.

If this is true, it must have a profound biological significance. It has: when functioning properly, it is an instrumentality for *race*-preservation as against *self*-preservation. This is evident at the lowest level of the unconscious in the senile degeneration by which the body eventually commits suicide. It is evident also at the highest level of consciousness in the role of the conscience as the champion of the interests of the race at the expense of the individual harboring him! Although psychiatrists are not unanimous, I am convinced that the Superego is present in the lower animals also, as an instinctive conscience guarding the safety of the herd. Trinitarian psychology explains nicely how the Superego gone wrong may torture the individual with no benefit to the race.

As the subconscious is a master of disguise, the will-to-death may take forms that will fool all but the experienced psychiatrist. Here is an agitator talking about his superior race and blood, his unconquerable will, and his irresistible determination to conquer the world or go down in the attempt, pulling down the rest of the world with him. Is he driven by the will-to-life-and-power? Or is not such reckless gambling with life sufficient evidence in itself that the

man is driven by the will-to-death, disguised as will-to-power, so as to evade whatever conservative controls may have been left in his personality? When one reads about the kind of will-to-power that Nietzsche visualized as the highest good and just what he would do with it after he got the power, one cannot help but conclude that he was driven by a disguised, insane will-to-spectacular-death. Many people in Germany seem to be afflicted with such a neurosis. They even have a name for it—*Götterdämmerung*—twilight of the gods. It is not unreasonable to assume that Wagner's Id sensed the ailment all around him and expressed it in *Der Ring der Niebelungen*. No wonder many Germans, especially the nazis, are extremely fond of that music—it expresses sonorously their subconscious longing for an epic end.

Not all self-mutilations are due to an internal conflict. One large class of them are instruments of warfare against others—passive in appearance, but very aggressive in intent and sometimes very effective. Children cry so as to have their way with their parents; women cry and even become sick so as to have their way with their husbands; the jilted lover threatens to shoot himself unless the young lady will marry him; Gandhi goes on a hunger strike to fight the British Government; and the Gold Coast native hangs himself at the door of his powerful enemy. The success of this type of warfare or aggression depends on driving a wedge between the Superego and the rest of the opponent's personality; or, failing that, driving a wedge between the opponent and the public conscience. The argument is "You drove me to this, my blood shall be on your head [conscience]." Or, "He drove me to this; regard him as a criminal."

In the light of all the foregoing, one can see an unsuspected psychoanalytic reason for the ancient friendly admonition, "Be good to yourself."

THE PARENTAL DEVOTION OF BIRDS

By ALEXANDER F. SKUTCH
SAN ISIDRO DEL GENERAL, COSTA RICA

MOST of us who have given even casual attention to the ways of wild creatures have from time to time witnessed acts of courage in the defense of home or young that have made our pulses throb with admiration. It may have been a mother raccoon returning heroically to rescue a cub who had lagged behind when danger threatened; or a parent bird defending her nestlings from a cat or a snake; or else we ourselves were the object of attack, when our well-intentioned visit to the nest was misinterpreted. We marvel at such dauntless heroism, and question whether we would possess the valor to confront enemies so many times greater and more powerful than ourselves, even in the defense of those we most love.

Of all my adventures among wild things, no recollections are more grateful to memory than those of their heroic acts in the defense of their homes. For nothing so warms the heart, even of the timid, as the sight of courage put forth in a good cause. Most of these recollections center about birds. Once, while bathing in a tropical river, my attention was drawn to a sudden commotion among the bushes overhanging the channel. A Song Tanager (*Ramphocelus costaricensis*) had her nest there. A slender green snake, about two feet in length, had surprised her by a stealthy advance and was devouring her spotted blue eggs. The tanager, crying loudly in her nasal voice, was fluttering about, trying to fight off the serpent. If she did not actually peck the lustrous green body, she certainly came within an inch of touching it. I fear that I was more the partizan than the disinterested scientific observer, for I no sooner became aware of what was happening than I began to look for a weapon—which, as usual, was not to be found when most urgently needed. As soon as I could lay hands upon a stick that brought the snake within reach, I rushed to the bird's assistance and knocked her green enemy into the water, just too late to save her eggs.

Meanwhile, the tanager had been hovering around her doomed nest, very nearly, if not actually, in contact with its assailant. This display of courageous determination surprised me, because where man is concerned the female Song Tanager is one of the most timid of birds at her nest. The green serpent was to the tanager in size as a boa or python from fifteen to twenty feet in length to a man. (The boa which the intrepid Waterton engaged in a wrestling bout amid the Guiana forests was, if I rightly recall, of far inferior proportions; and few men, I imagine, would care to repeat his exploit.) The fact that the tanager's defense against the snake was ineffective did not prove that she had failed to inflict punishment upon it; for I once watched a serpent of another kind, a mica, mortally wounded by bullets, continue to gorge upon the contents of the nests in a colony of Lawrence's Caciques. A ravening snake appears to be insensitive to pain and almost insensible to danger.

Often I have myself been the object of attack by too-zealous parents unable to understand my benevolent curiosity. One of the vivid recollections of my boyhood is of an adventure with a parent Bob-white Quail. Riding along a winding country road on my bicycle, I saw her cross with her covey of downy

chicks ahead of me, and dismounted just in time to catch one of the stragglers. But the old bird, noticing the fate of her chick, turned and dashed toward me so belligerently that I dropped my tiny captive and retreated. An angry barnyard hen will sometimes make as fierce an attack in defense of her chicks.

Years later, a pair of Catbirds (*Dumetella carolinensis*), nesting in a thorny barberry hedge between two houses in the suburbs of a great city, gave a fine display of courage and cooperation in the defense of their nest. During the female's frequent absences from incubating her three blue eggs, her mate would almost invariably perch in a little hawthorn tree hard by the nest, where he could keep watch over it. Here he stood guard in silence; but upon the return of the female he went off to a more distant ash tree to resume his sweet music. Whenever I came near his treasures, he advanced very close to me, tail spread and wings quivering, hopped excitedly about, and uttered loud mews. If I held my hand above the nest, the female Catbird would strike it with her feet. After the eggs hatched, both grew bolder in the defense of the nestlings. The mother bird would now not only strike my hand, but actually alight upon the back of it and peck me vigorously with her slightly deformed bill. The blows were rather painful, and at times drew a few drops of blood. If I turned the palm of my hand upward, she dared not rest upon it, but pecked from the side. Meanwhile, the father would flutter about my head, sometimes striking me. All in all, this was the most vigorous mauling I have ever received from any pair of birds.

The human hand, with its five long, mobile, grasping fingers, must seem a terrible instrument to creatures with less versatile forelimbs. I imagine that they look upon it with the same degree of aversion and dread as we do the tentacles of an octopus, the fangs of a serpent, or the sting of a scorpion. The Catbird, who doubtless had enjoyed no previous opportunity to study the mode of action of a hand, seemed instinctively to know which way the thing worked, and made her attacks with due caution. While taming a filly, I found that she would take food from my hand, and nuzzle my face, long before she would willingly submit to being touched with my fingers. She appeared to have the same dread of them as the Catbird.

In the forests of Panama, a male Slaty Antshrike (*Thamnophilus punctatus*), a bird somewhat smaller than the Catbird, defended his nest with equal valor. He was standing guard beside the little moss-trimmed cup when I attempted to lift out one of the nestlings. Fluttering his spread wings, expanding his tail into a black fan tipped with white, raising the blackish feathers of his crown, and spreading the slate-colored plumage of his back to reveal the white patch usually concealed in its center, he resembled a wild Indian in full panoply of war. Then, darting forward, he bit the tip of a finger—I suppose with all the might of frenzied parental devotion, yet so lightly that I scarcely felt the nip. Twice he repeated his daring assault, then retreated a little way. Meanwhile his mate, creeping over the ground close by, tried to lure me away by the familiar "broken-wing" ruse.

Many other birds have displayed signal courage in defending their nests from my well-meant but probably terrifying intrusion. I recall a male Groove-billed Ani who forcefully buffeted the back of my head whenever I visited his nestlings in the thorny orange tree. A Verreaux's Dove, who could not easily be frightened from its overhead nest in a coffee plantation, gave a stinging wing-blow to the mirror I held up to see the contents of the shallow cup—stinging, I fear, only to its wing. Then

it dropped to the ground and gave one of the best exhibitions of broken-winged helplessness I have ever witnessed. A Short-legged Wood Pewee, one of the smallest and weakest of the flycatchers, made most spirited demonstrations whenever I visited his nest, dashing close by my ears with angry snaps of his little bill. Trespassing birds far larger than himself were treated in the same fashion.

The literature of natural history, both dryly scientific and that intended to make more exciting reading, is full of accounts of the reckless courage which birds and mammals at times display in the defense of their young. Many an egg collector has had cause to rue his climb to a hawk's eyrie defended by parents strong of talon and dauntless of heart.

Some birds display their fortitude by clinging staunchly to their nests in the face of danger, rather than by bold attack. Chiefly, these are of kinds whose coloration renders them inconspicuous; to move would be to cancel the value of their protective coloration and to catch every watchful eye. Hence they remain sitting motionless in the face of an enemy until it is almost upon them, as though hoping against hope that they had not been seen. Yet it is not always the neutrally colored bird who remains faithfully at her post of duty: a Robin and a glittering hummingbird have permitted me to touch them lightly as they sat. But the bravest and most devoted of all the incubating birds I have ever known was a tiny female Yellow-thighed Manakin (*Pipra mentalis*). Clad in dull olive-green, quite lacking the brilliant scarlet that adorns the head of the black male, she was a most inconspicuous object as she sat in her shallow nest, hardly bigger than a watch glass, in the undergrowth of the tropical forest. She clung stubbornly to her nest, and allowed me to smooth the feathers of her back, touch her breast and bill; even shaking the branch that supported the nest would not cause her to forsake it. Since she could not easily be made to leave, when I wished to learn whether her eggs had hatched, I was obliged to push my fingers beneath her breast and feel. I found her clinging to the little cup with her feet. She provided a unique object for photography; she was the only mature bird I have ever known who would allow herself to be gently pushed about on the nest into just the pose the photographer desired. Yet away from their nests, these manakins are not devoid of a wholesome caution in the presence of man.

Birds that breed in burrows often remain on their nests with incredible disregard of their personal safety. This is especially true when the nestlings have just hatched, for it is then that parental devotion is at its most fervent pitch. I have opened the burrow of a Blue-throated Green Motmot, and of a Green Kingfisher, and lifted the parent bird unresisting from its newly hatched nestlings. A big Ringed Kingfisher remained upon her eggs with equal bravery; but her powerful beak forbade familiarities. Yet all of these birds were free to escape, since I had opened their burrows at the rear, and they might have slipped down the entrance tunnel to the outer air.

But despite all the steadfast devotion of birds to their nest, their zeal in its defense, their reluctance to forsake it even in the face of enemies far larger and more powerful than themselves, less than half of all bird nests remain inviolate until the young are fledged. Studies have been made of the nest-losses of many kinds of birds in the most varied regions. Only occasionally, where sufficient nests to be statistically significant have been followed through, has the number of losses been much below 50 percent. In the North Temperate Zone,

the premature loss of from 50 to 60 percent of all open nests seems to be the rule; often the destruction is considerably greater. In the tropical forest, the loss of nests is sometimes as high as six in seven. This will not surprise us, when we remember that the enemies of birds are numerous, while the birds themselves—for all their zeal—are for the most part harmless creatures whose only defense lies in flight.

But what does seem incompatible with the parent birds' manifestation of devotion and concern is the fact that they nearly always survive the loss of their eggs or nestlings. Very infrequently one finds evidence, in the form of feathers scattered about and below the nest, that the parent bird has shared the fate of its offspring. And even this telltale sign of disaster may be misleading, for I have known parent birds to leave many feathers behind, yet survive to build another nest. Nearly always, the despoiled nest is followed by another and another, until at last a brood is fledged, or the breeding season draws to a close. I have known a pair of birds to build four, five, or even six nests in a season, yet not raise a single nestling until it was fledged.

Are we to conclude from this that the solicitude of parent birds—their cries of distress, their attacks and feints of attack, their steadfast clinging to the nest in the face of danger—is all a sham and a bluff; that in their boldest resistance to the intruder they are acting a part, just as when they flutter away over the ground feigning a broken wing? Can it be that they have no real feeling in the matter, and not the least intention to sacrifice their lives in the defense of their offspring?

Birds do in fact at times give up their lives in the defense of their nests. If Audubon's famous painting of the Mockingbird in the rattlesnake's mouth is based upon actual observation, we have here a case in point. In the defense of its nest the British Cornerake is said to attack a dog or fight a rat until too crippled to escape. I personally have never witnessed a grown bird fall a victim to the assailant of its nest; but then it is not often that the watcher is at hand at the moment the calamity occurs. Yet many a bird, defending its nest or merely remaining steadfast upon its eggs, has placed itself within my power to kill it with a stick or even my hands, had I been so inclined.

We have seen that with most species of birds the eggs or nestlings are destroyed in half or more of all nests. At times the destruction is effected by some small marauder, weaker than the owner of the nest, during an interval when both parents are absent. But usually the destroyer is more powerful than the parent birds. Were these to offer a determined resistance, the outcome of the conflict could hardly remain in doubt: the parents must die along with their offspring. Even if they succeeded in beating off the assailant at the expense of mortal wounds, the nestlings would succumb from lack of attention. In many species, if only the male died, the female might care for her family alone; and I have known male birds of several kinds to be successful in raising nestlings whose mother disappeared after they were feathered. But with most species of birds, the economy of the nest is such that if the female be lost before the nestlings are covered with plumage, the eggs must spoil or the nestlings die of exposure. Even making allowance for exceptional cases, I believe that by a policy of "resistance unto death," nearly half of the breeding adults would each year not only fail to reproduce themselves, but perish in the attempt to reproduce. The remaining half of the breeding birds would doubtless not suffice to maintain the population at a constant level; for many a fledgling that

leaves an undespoiled nest fails to reach maturity; and the adults themselves face many dangers.

Thus it appears that natural selection must itself set a limit to parental devotion. For the parents to sacrifice their lives in vain attempts to preserve their offspring, or even in the successful defense of their young, would be a heroic but futile gesture. The struggle for existence among wild creatures is too severe to allow such chivalrous renunciation of self. Among highly social animals, such as man, the social Hymenoptera, and perhaps even beavers, Brown Jays, and a few other vertebrates, the sacrifice of an adult in the defense of the young may be of positive biological value; but certainly not among creatures with which the single individual or pair is alone responsible for the care of the offspring—for they have no orphanages, and adoption is rare or unknown.

In an economy under which all or nearly all of those individuals who lose their lives in an attempt to shield their offspring fail to leave progeny, the heroic race cannot long survive. I believe that the elimination of individuals inclined to take too great risks in the defense of their offspring is going on, on a small scale, all the time in many species. Thus it would be impossible for any species or race to arise, through natural selection, in which all or the majority of the individuals fight to the last breath to preserve their eggs or young. It is not impossible that whole species may have become extinct through no other cause. This is especially apt to occur when a new predator, with whose prowess and activity the native birds are unfamiliar, invades their territory. Natural selection certainly cannot forestall the development of strong parental solicitude, nor the manifestation of that solicitude in demonstrations of anger or attempts at defense when the young are endangered, but it sets a strict limit to those demonstrations and that defense. The parents must not often endanger their own lives, nor habitually enter into conflicts of which the issue is in doubt.

Often, when we visit a bird's nest, we witness behavior which is a compromise between parental devotion and the instinct of self-preservation. Anguished parenthood would—and sometimes does—throw itself recklessly upon the intruder. But more often it is withheld by that prudence without which its kind would cease to exist. The bird may dash boldly toward us—only to swerve harmlessly aside when nearly within reach. It may hover in the air above us and utter shrill screams of distress. Or else it may shower upon some inanimate, or even animate, substitute the pecks it dare not inflict upon us. A female Great-tailed Grackle, whose nest in a coconut palm I used to visit, would alight upon one of the great fronds and give it angry pecks while I looked at her nestlings close by. When I climbed to a nest of Brown Jays in a willow tree beside a tropical lagoon, the most zealous of the attendants would administer punishment to the surrounding boughs, or else alight on a banana leaf close by and tear it to shreds with its powerful bill. Blue Jays will also hammer vigorously at a branch while a human intruder is at their nest. Under similar circumstances, Ravens behave in even more spectacular fashion. "When the young are in danger, you often see the old birds work themselves into such a temper that they pitch down and tear grass up by the roots, looking a very picture of impotent rage. On one occasion, under such conditions, we saw a bird settle on a sheep's back and tear the wool off it, to everyone's great amusement except the sheep's" (Gilbert and Brook, *Secrets of Bird Life*, London, 1924). Prairie Falcons, when their nests are disturbed by men, sometimes strike and even kill other birds in the vicinity, making them

the innocent victims of outraged parental devotion (Bent, *Life Histories of North American Birds of Prey,* Washington, 1938).

IT APPEARS to be generally true that wild creatures are instinctively aware of the strength and prowess of their hereditary natural enemies, and avoid risking their lives in the defense of home or offspring against such enemies as are likely to overcome them. This principle might be briefly designated the "Law of Prudence." It applies not only to birds and mammals, but to cold-blooded animals as well. Once I watched a Red-throated Caracara (*Ibycter americanus*), a big black hawk with a white belly, attack the corrugated carton nest of a kind of large black wasp with a formidable sting. The caracara subsists largely upon the larvae of wasps, and is a master of the art of opening their hives. Attracted to the scene of impending conflict by the bird's hoarse, raucous calls, I prepared to witness a thrilling and hotly contested battle between hawk and wasps. But in this I was disappointed. From the first, the wasps seemed to recognize the mastery of the caracara. They hovered about it in a black swarm. A few apparently attached themselves to its plumage, for it shook its head, scratched its body with a foot, and appeared to pluck one or two from its feathers. But on the whole it took little account of the insects, which soon ceased their attacks and flew about in helpless anger; while the caracara, hanging back downward, proceeded to tear away the corrugated gray envelope of the nest and to devour at its leisure the contents of the brood combs.

These wasps, although they lost all their young brood, lived to establish a new nest on the wall of my house—behavior biologically more sound, if less inspiringly heroic, than losing their lives in a vain attack upon the caracara. Not long after their new corrugated fabric was completed, the house was invaded by a horde of brown army ants. These incursions were repeated at brief intervals during the course of several weeks. When the ants discovered the nest of the big black wasps, they filed in long, hurrying columns to the attack. The wasps merely lined up around the single inch-wide orifice at the top of their nest, their bodies entirely inside, their heads in a ring just within the rim. Whenever an ant passed over the edge of the doorway, it was easily pushed back by the defenders. The brown hordes picked out each weak spot in the corrugated carton walls and attempted to open a breach. But whenever a small gap was made, it was defended from within in the same manner as the permanent entrance. For two hours I watched an exciting siege, an attack upon Troy in miniature, right on the outer wall of my dining room. At length the Greeks admitted defeat and drew off their forces, leaving the Trojans in unshaken possession of their citadel. Neither attackers nor defenders, so far as I could learn, suffered a single casualty. The wasps knew, instinctively, when prudence was the better part of valor, as with caracara, and when they could put up a successful resistance.

Of all the numerous kinds of curious wasps' nests attached to my walls and rafters, none other escaped destruction that eventful afternoon; for either their occupants were smaller and weaker than the black *guitarrónes,* or else their houses were more open. And in every instance, apparently, these less powerful wasps fled without a real attempt at defense, although a few were trapped in their nests and fell prey to the Echiton ants. The chief booty, however, consisted of the soft white larvae, which in long, victorious columns the ants bore down the walls and out through the grass in the yard. In many cases, after the departure of the ants, the wasps returned

to their desolated homes, and began to fill the empty brood cells with eggs once more.

The army ants made several other afternoon attacks upon the big gray nest, but always with the same lack of success. The corrugated fortress was clearly impregnable by day. Finally, the Echitons attempted a nocturnal attack, with a very different outcome. The wasps, big-eyed, diurnal creatures, had clearly lost advantage in the face of their nearly eyeless opponents, to which night or day seem to be as one. Many fled the doomed nest and settled upon the walls of the house, or else flew in to the lamplight through the open door, and so gave me notice of what was taking place. Others were trapped inside and overpowered, and their lifeless bodies dragged out along with the larvae, each by a whole squad of toiling ants. But next day, the numerous survivors returned to their childless home, and began to fill the brood-combs anew. Here, again, the instincts of the wasps led to the maintenance of a breeding population of adults rather than to the preservation of the young brood. Biologically, an adult in the reproductive period of life is far more important than an immature individual; for, under natural conditions, the chances of any newborn animal's reaching reproductive maturity are not high. The breeding adults are a selected, and therefore more valuable, group than the infants of the species.

My experience with the wasps and ants led me to introduce a modification to the "Law of Prudence," which is that wild creatures as a rule avoid risking their lives in the defense of home and offspring against an enemy powerful enough to overcome them *under the conditions of the attack.* For it is evident that while adults may put up an effective defense under certain conditions, with altered circumstances they flee from the same enemy. Many birds' nests are despoiled during the night, possibly by enemies that the birds, which are helpless in the dark, would be able to drive away in the daylight.

These responses to attack, whether by flight or defense, are instinctive rather than rational, or based upon individual experience. The same wasps that appear to know so well what course to pursue when attacked by a hereditary natural enemy, are most stupidly blind where man is concerned. When a swarm has settled down to build a nest on a house, where they would be a menace to the inmates, it frequently happens that there is no way to discourage them short of extermination. If a few are killed at a time, the survivors return; and they must be attacked again and again until all are dead. They have not yet learned the ways of man, and appear to be incapable of learning them from individual experience. Similarly, birds upon a desert island fall easy prey to cruel, avaricious men.

THE "Law of Prudence" applies to the procuring of food no less than to the defense of offspring. Just as a wild creature's chances of rearing its young to maturity are at best so small that nature cannot afford to let it lose its own life in defending them against a more powerful assailant, so its natural enemies, whether larger animals or parasites, are so numerous that it would jeopardize the existence of its kind if it habitually preyed upon animals whose strength or weapons of defense made them a doubtful quarry. The squirrel and the jay enjoy an occasional egg, but will not attempt to steal one from a hawk's nest while the owner is present; the eagle hungers for the newborn antelope, but seeks to surprise it away from its mother rather than brave her sharp prongs. I believe that no wild animal normally obtains its food in a manner so dangerous as, let us say, the occupation of a deep-sea fisherman in

northern seas before the mechanization of the industry. Those animals who appear to win their food, or that of their offspring, in a most desperate and hazardous fashion, upon closer study are found to be so expert at their trade, or so well-provided with bodily defenses, that actually they run little risk. The caracara, which subsists largely upon the larvae of wasps, would seem to be doomed to a life of cruel punishment and distress; yet I saw that in attacking a hive of one of the fiercest wasps of this region, it had things all its own way.

Snake-eating birds, which prey upon venomous as well as nonvenomous species, would appear to lead a precarious existence; but a little reflection will show that this cannot be so. A bird like the Laughing Hawk (*Herpetotheres cachinnans*)—the *Guaco* of Central America—whose principal, if not sole, diet is snakes, needs on a conservative estimate 365 of these reptiles a year for its own consumption. At a nest I watched, the male brought a snake every morning and evening for his mate and downy nestling; whence I conclude that a breeding male must capture upwards of five hundred serpents in a year. In order to make so many successful attacks upon snakes, he must be a master of his art, not an experimenter or a bungler. He must know to a nicety which snake he can safely seize, and which is too powerful for him. Although little is known of the rate of reproduction of these hawks, it appears to be slow, indicating that the adults are long-lived. The poets delight in describing long-continued, spectacular conflicts between the eagle and the serpent it has grasped in its talons—none more thrilling than that which opens the first canto of Shelley's "Revolt of Islam." It seems a pity to cast doubt upon the factual accuracy of such stirring passages in poesy; yet in the interest of truth I must record that I have seen hawks and eagles sailing through the air with snakes in their talons more times than I can recall, and always the serpent, far from endangering the life of its captor, hung a helpless victim in his talons. We may recall that in some of the great serpentaria where antivenins are prepared, the attendant who allows himself to be struck by one of the snakes under his charge is deemed guilty of unpardonable carelessness, and suffers a pecuniary fine in addition to the painful treatment for snake-poisoning.

Those wasps which store up paralyzed tarantulas or other great spiders as provender for their larvae appear also to engage in a desperate business; but in reality, as the studies of Petrunkevitch and others have shown, the spiders are terror-stricken at the approach of these skillful huntresses, and fall almost unresisting victims. Perhaps the terror of the rabbit when cornered by the weasel, and of small birds when overtaken far from cover by a hawk, is typical of all animals when face to face with the creatures that habitually prey upon them.

But the most skilled experts at times make mistakes at their trade; so these hunters of large or dangerous creatures sometimes misjudge their prey and pay dearly for the error. An example of this is the Osprey who sinks his talons into the back of a fish heavier than he can lift, and is drawn under water and drowned by the intended meal. Once I saw a Laughing Hawk pounce down upon a large black-and-yellow mica crawling through a pasture. The snake reared up; the hawk, evidently surprised by its length, at once took flight and did not repeat the attack, not caring to risk its neck in an encounter of uncertain outcome. Such mistakes appear to be rare in the lives of hunting animals. Their slow rate of reproduction, as compared with that of the creatures upon which they prey, is proof of this.

Last October, at the edge of the forest beside my house, I saw the act of the

Laughing Hawk and the mica repeated in all its essential details, but with actors of far smaller size. A female Tyrannine Antbird (*Cercomacra tyrannina*), an insectivorous bird about the size of a sparrow, had discovered a big, brown, hairy spider in its lair between two leaves it had bound together with cobweb. When threatened by the antbird, the spider raised its four front legs, keeping the two on each side together except at their tips, where they were slightly separated, so that the legs jointly bore considerable resemblance to the pincers of a scorpion. Whenever the bird drew near, the spider waved these raised and threatening appendages, and then she would draw back. It was clear that the little antbird was tempted by this large and succulent morsel, and it was just as plain that she feared it. Perching at a respectful distance, she stretched forward her neck to seize it in the tip of her bill, but she did not stretch quite far enough. Finally prudence overweighed appetite, and the bird flew off in search of less formidable game. The spider measured possibly two inches across the spread legs, and was a big morsel for a bird only five inches long.

The prudence of the foraging Wrentit (*Chamaea fasciata*) is described by Dr. Erickson in her monograph of this little bird of western North America:

> The attack on larger prey, such as centipedes two or three inches long, as seen in caged birds, is a prolonged process which combines dexterity and speed. The lashing centipede, to a wrentit, is formidable and inspires obvious fear. It is circled and watched at length, and often succeeds in disappearing into the leaves. Otherwise, the bird finally recognizes an opening, there is a quick thrust, grab, and toss, the centipede lands several inches away, and the tactics are resumed. With each attack the vigor of the prey is reduced. Finally, the wren-tit dares hold it with foot or bill. . . . Once, a captive wren-tit pulled to pieces and ate in the course of half an hour a very active four-inch angleworm, an operation which was not repeated though the opportunity was often provided. It was accomplished with extreme awkwardness, both because of the obvious fear of the bird for the twisting worm and because when a grip was secured the slimy length pulled through the grasping foot.

Further evidence of the habitual prudence of birds in choosing their prey is found in the eyemarks of many caterpillars, notably those of the swallow-tailed butterflies (*Papilio*), their habit of raising their foreparts or lashing from side to side when threatened, and similar markings and attitudinizings of small creatures that are perfectly harmless and apparently quite good to eat. It would be difficult to account for the evolutionary development of such devices were they not at times effective in frightening away hungry but timid birds and perhaps other insect-eaters as well. Several observers have described the startled behavior of small birds that suddenly came face to face with the wide-eyed, serpent-like mask of the caterpillars of the Tiger Swallowtail and related species.

In times of scarcity and famine, a different story must be told. Then, half-famished animals are driven to take unequal chances to procure the means of continued life. Wolves attack villages, braving the deadly weapons of men; animals ordinarily cautious are lured into traps. But these are exceptional circumstances.

Yet occasionally, even when there appears to be no dearth of food, creatures of two species will engage in long, fierce conflicts of which food is the coveted prize. Social insects, especially ants and bees, seem most frequently to wage such deadly battles. At times bees of two kinds join in hottest warfare, one seeking to carry off the sweet stores of the other. The dead and dying bestrew the ground, opponents locked together in deathgrips. Or else ants attack a hive of bees, which valiantly defend their home, slaying many of their adversaries, but paying several lives for one. Such

struggles appear at first sight to present exceptions to the "Law of Prudence," but the exceptions are more apparent than real. In all the battles of this sort that I have witnessed, the opposing hosts were rather evenly matched; and if one lost more heavily than the other, it had more soldiers to spare. Each side had a prospect of victory. If the attackers won and carried off the booty, they paid for it with many lives. But then the hive's stores of nectar are gathered only at the price of the workers which wear out their lives in quest of it. Perhaps, after all, a full storehouse won by a victory in which many lives are sacrificed, costs less per drop than nectar slowly gathered from its primary sources in pacific fashion. And if the defenders are victorious and save their hive at the expense of many of its inhabitants, the survivors carry on the work of rearing the young brood. Their situation is quite different from that of more solitary animals; comparable to that of man.

THERE are two reasons, then, why we should not expect to see birds engage often in life-and-death struggles in the defense of their nests and young. First, were they to resist habitual predators more powerful than themselves, the existence of their kind would be placed in jeopardy. Second, they are not often called upon to do more than threaten weaker animals that approach the nest, for these would jeopardize the existence of their species if they attacked stronger creatures in their quest for food. So long as more certain prey is available, animals prefer not to attack others that are an even match for themselves. Sometimes, of course, a weak marauder attempts to rob a nest in the absence of its owners, and is put to ignominious flight by their sudden return.

Some years ago, I spent many hours watching a nest of a pair of Laughing Hawks, situated a hundred feet above the ground in a cavity in the trunk of a huge tree standing at the edge of the forest. Through field glasses, I could sometimes see a single downy nestling, buff-colored with a black mask like that of the adults, as it tumbled about in its lofty nursery. The mother hawk passed most of the day sitting in the cavity beside the nestling, and during her brief absences went no farther than a tree in front of the doorway, whence she could keep an eye upon her youngster while she preened, scratched, and stretched her wings. The male hawk brought all the food, arriving morning and evening with a snake from which he had already bitten the head. Alighting upon a bough in front of the nest, he would call his mate to come out and receive the prey. Then the two would celebrate the event with a long-continued duet of loud, far-carrying cries.

One afternoon, while the female hawk rested in the tree in front of the nest, I suddenly became aware that a long, black tayra—a larger relative of the weasels—was climbing squirrel-like up the great trunk toward the eyrie. He advanced toward the cavity in a direct, unhesitating fashion, as though he had already spotted it from the ground. The Laughing Hawk failed to notice the beast, or at least gave no outward indication that she had seen him, until he was almost within reach of the wide doorway of the eyrie. I desired intensely to complete my study of the only Laughing Hawk's nest I had ever seen; but the situation was so charged with possibilities of intense, dramatic action that, waiting breathlessly for the outcome, I made no move to frighten the advancing tayra. How effective was this unremitting guard the mother hawk kept over her offspring? Only when the tayra was on the verge of entering the hole did the hawk bestir herself. Then, uttering a low cry, she darted directly toward him. But he snarled, baring

strong fangs; and she dropped away, to return to her former perch.

The hawk's resistance was so weak and ineffective that it did not give me time to prepare for my own next move. I had expected that she would at least retard the tayra's progress toward the eyrie, but he hardly altered his pace on her account. When she returned tamely to her watching post, leaving the beast at the very doorway of her nest, I felt in my situation almost as helpless as the little hawk in the eyrie. I could think of nothing to do except to shout and wave my arms. By continued noise and gesticulations, I succeeded in driving the tayra to the ground, but not before he had reached into the cavity and killed the nestling by a stroke of his forepaw.

I was disappointed in the mother hawk's fainthearted defense of her nestling. I had expected something more heroic from such watchful motherhood. Such attentive, unremitting guard, to be capped by so slight a gesture of defense! But pondering over the event at a later date, I saw clearly that the outcome could not have been other than it was. The Laughing Hawk, intrepid snake-eater though she be, is slow of flight and weak of talon, not to be compared in prowess with such winged furies as the Peregrine and the Goshawk. A marauding, voracious toucan or a squirrel might have been put to flight, but she was clearly no match for the strong-fanged, catlike tayra. She could have done nothing more than offer herself a sacrifice upon the altar of parenthood; and the offering would have been garnished by the tender body of her nestling. Nature could not permit such a sacrifice without jeopardizing the existence of the whole race of Laughing Hawks—whose loss would result in a widespread upsetting of her balance, with snakes increasing and each year destroying a larger number of birds' nests, while birds declined in numbers. It was more important for the Laughing Hawk to continue to live that she might make another attempt to increase her kind, than that she should die heroically, a beautiful sacrifice which could profit only her enemy the tayra. Among Laughing Hawks there are no bards to immortalize a glorious death for the inspiration of future generations of hawks. Natural selection had set a limit to her parental devotion.

BOOK REVIEWS

A MEDICOPHARMACEUTICAL CLASSIC

Pharmacopoeia Londinensis of 1618. Reproduced in Facsimile with a Historical Introduction by George Urdang. vii, 299 pp. $12.00. 1944. State Historical Society of Wisconsin, Madison.

IN 1914 a prominent druggist of Madison, Wis., Albert Henry Hollister, and his wife Kittie E. V. Hollister bequeathed to the Wisconsin State Historical Society a sum of money to be known as the Hollister Pharmaceutical Fund. It was decided by the Society, with the consent of the executor of the will, to use half of the income from the fund to reprint "rare and valuable works in the field of pharmaceutical history and development."

The first reprint to be issued with the aid of this fund was the *Pharmacopoeia Augustana of 1564,* which appeared in 1927. Now the exceedingly rare *Pharmacopoeia Londinensis* has been issued in a magnificent facsimile edition. This by itself would entitle the Wisconsin Historical Society to receive the thanks of the learned world. But this facsimile is more than a reproduction of a rare old book. Preceding the text is an introductory essay of eighty-one pages entitled "The History of the *Pharmacopoeia Londinensis*" written by the brilliant and scholarly George Urdang, Director of the American Institute of the History of Pharmacy in Madison. In masterly fashion Dr. Urdang has provided an analysis of the text, relating it not only to works that preceded and succeeded it elsewhere, but placing the work in its proper setting in the social, economic, and political atmosphere of its time.

The London *Pharmacopoeia* has a strange and interesting history. The idea for such a work seems to have first been recorded in the *Annals* of the Royal College of Physicians on June 25, 1585. But it was not until May 7, 1618, that it was finally issued. It had been eagerly awaited not only by the physicians and apothecaries of England but also by the representatives of medicine and pharmacy in western Europe. This was not because it was the first pharmacopoeia (there had been many earlier works) but because it was the first such work to be held as authoritative for a whole country, i.e., England. The many European compends that had preceded it were gotten up for municipalities or city-states.

Then a curious thing happened. The issue of May 7, 1618, of the London *Pharmacopoeia* was suppressed, and a new version was made public on December 7, 1618. Even a cursory examination of the two issues shows that the difference between them was more fundamental than the mere substitution of one title page for another.

Although much has been written about, and many scholars have labored over, the problem posed by the two issues of the first edition of the London *Pharmacopoeia,* it remained for George Urdang to provide what will almost certainly come to be regarded as a complete, correct, and satisfying solution to the mystery. This solution cannot be given here because it is too complicated to compress into a small space, but I am convinced of its soundness.

The first and suppressed issue of May 7, 1618, seems to have been printed in a small edition, and only six copies are known to have survived. The facsimile, beautifully reproduced in an edition of five hundred copies, is from the copy now in the British Museum.

I can do no better in concluding my review of this noteworthy contribution

to pharmaceutical history than to quote from the final paragraph of Urdang's introduction:

> Well-nigh forgotten and lost, deliberately misrepresented, this first issue once more makes its appearance before the medico-pharmaceutical world. It has an interesting history. What is more, it is interesting in itself as the first Anglo-Saxon attempt at an official formulary. Moreover, it is a reliable witness of what the learned medical eclectics of the seventeenth century regarded as the necessary armament of the average physician and apothecary of their period.

MORRIS C. LEIKIND
LIBRARY OF CONGRESS
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TWO PLANT COLLECTORS IN BRAZIL

Brazil, Orchid of the Tropics. Mulford and Racine Foster. 314 pp. 1945. $3.00. The Jaques Cattell Press, Lancaster, Pa.

THIS recent book dealing with plant collecting in Brazil might appropriately have been given a less general title. The authors are well-known horticulturists, who in the past few years have specialized on the family Bromeliaceae, of which the best-known representative is the pineapple. Their primary purpose in collecting in Brazil was to gather live specimens of plants of this family for their Florida garden, although plants of other families, especially orchids, were collected also. The expedition was eminently successful, even though some of the choicest plants died during the long sea voyage or during fumigation at the time of their entry into the United States. Fortunately, however, the authors were wise enough to make herbarium specimens. In this way they have made a worth-while contribution to science, for they discovered more than forty new species and varieties of Bromeliaceae. This is not wholly surprising, for general botanical collectors have been apt to neglect these plants, because, like the cacti and the palms, they are among the most difficult to preserve properly. They are hard to dry, and, although they are often very large, it is necessary to collect the whole plant. The resulting prepared specimens are therefore bulky and awkward to transport.

The authors began their collecting in the state of Bahia, and visited especially Jacobina and Ilhéos, one of the classic collecting grounds of the great botanist Martius. This is a region of rain forests, and in such habitats the Bromeliaceae are mostly epiphytes, or "air plants." The natives usually call them parasites, but they are not, for they use the trees only as footholds. They grow so high in the trees that getting them is frequently a problem, even though some of the natives are expert tree climbers.

After a return to Rio de Janeiro, an expedition was made to the little coastal state of Espírito Santo. Here, near a gigantic shaft of granite known locally as the "Dedo de Deus," or "Finger of God," the authors discovered a spectacular new species, which Dr. L. B. Smith has named *Aechmea orlandiana*, after the Fosters' home city of Orlando.

This first trip to Brazil ended with an automobile excursion to Paraná, a region in southern Brazil floristically distinct from the more tropical sections. The following year (1940) the authors returned to Brazil and made trips to the states of Minas Geraes, Espírito Santo, and to the large far-western state of Matto Grosso.

Plants are foremost in the minds of the authors, but passing observations are made on insects, birds, frogs, and monkeys. The comments reveal also their high esteem for the people of Brazil, a natural consequence of the friendly fashion in which they were everywhere received. The accommodations were rather primitive in some instances, but the best hospitality available was always offered, despite the fact that many Brazilians were unable to comprehend the authors' interest in "parasites."

The literary style of the book leaves much to be desired, and the numerous solecisms are disconcerting to the reader, as are the often misspelled scientific names. The attempts at philosophizing and "fancy writing" are frequently overdone, as for instance: "In Jungle, the fecund mother of plant life, we find a peace and contentment that never knows the fear of storybooks. We were embraced by great arms of chlorophyll full of the love of life, the constancy of life, and the nothingness of death." However, much can be forgiven the authors by reason of their obvious enthusiasm for their subject. The book is beautifully illustrated by 137 photographs and four colored plates, as well as by several clever drawings by Mr. Foster.

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OF INTEREST TO STUDENTS OF SNAKES

An Annotated Checklist and Key to the Snakes of Mexico. Hobart M. Smith and Edward H. Taylor. 240 pp. 1945. 50 cents. U. S. National Museum Bulletin 187, Washington.

THE title of this book might remind one of the man who was reading an encyclopedia and when asked how he enjoyed it replied that it was interesting reading, but that the plot was somewhat broken.

Smith and Taylor have lavished an immense amount of work on what they state is a temporary steppingstone in a rapidly developing field of research. Their effort will not be as ephemeral as they believe because it is built on a rock of sound common sense, as indicated by the eleven-page introduction. The book may well serve as a model for future checklists as it contains many improvements over those with which the herpetologist now struggles.

Remembering that their book is for the convenience of the student, the authors have thoughtfully arranged genera and species alphabetically. They adhere to specific names unless intergradation is known to occur. A "species" is defined as: any population isolated reproductively, geographically, or morphologically, or a total ensemble of characters in which at least one character always distinguishes the population from all others.

The writers explain their use of the terms "form," "race," "group," and "section." Unfortunately, every authority has a slightly different meaning for some of these terms, and it would be much simpler to abandon them altogether. The stand on primary and secondary homonyms is what all herpetologists have long desired—the suppression of only primary homonyms. The reason given for not suppressing secondary homonyms is that careful examination would be required, including the poorest and least known portion of literature and educational or semipopular works, and sanctioning the activities of the "professional name-giver."

That Mexico probably has a richer fauna than any other area of the globe of equal size is their claim, based on K. P. Schmidt's statement that Mexico acted as a very important faunal paleopeninsula and to a lesser extent as a faunal neopeninsula!

The body of the book is excellently arranged. A student who is familiar with the genera can most easily locate the page by a glance at the table of contents; others can run down the genus in the first key. Thereafter each genus has its own species key. An innovation of interest is the inclusion of species under the genus heading, giving the total number of species and the number known from Mexico.

Specifically, parentheses for authors' names are used only where a species has been transferred from another genus. The synonymies include a reference to

the original description, and original descriptions to all synonyms having type localities in Mexico; references to known illustrations; citation of the first appearance of the name-combination used and reference to any other work considered pertinent. The type number, locality, depository, and range is given for each species.

Except for a complete index the book closes with a list of species by states. This list discloses that only one species has been recorded from Aguascalientes, 4 from Tlaxcala, and 5 from Queretaro, as against an average of about 40 or more for the remaining 28 states. One immediately wants to set off for Aguascalientes, until a glance at the map shows that all the three poorly represented states are surrounded by states with goodly lists of species. This illustrates the unfortunate necessity of using political subdivisions instead of ecological areas. If Aguascalientes had perchance been included as part of one or more of the contiguous states, nothing out of the ordinary would appear; and, on the other hand, there are doubtless many areas larger than Aguascalientes that have never been herpetologized at all.

The book is a "must" for any student of Mexican snakes and it will doubtless remain the standard book of reference for many years to come.

CHAPMAN GRANT

SAN DIEGO, CAL.

A SAILOR'S HANDBOOK AND A WOODSMAN'S GUIDE

Science of the Seven Seas. Henry Stommel. 208 pp. 1945. $2.50. Cornell Maritime Press, New York.

THIS is a handy and concise popularization of the essential facts of physical oceanography and meteorology, and, considered from those branches of science alone, a successful work. However, the treatment of Darwin's coral reef theory and Wegener's continental drift hypothesis are worse than inadequate, since mere mention of them without stating opposing views leads to the impression that they are the accepted theories for the phenomena concerned. While admitting that he is not a biologist, the author appends a collection of photographs of marine life. This part of the book would have been improved by a better selection of illustrations—the combination of dingy views of moth-eaten museum groups with Ewing's interesting deepwater photographs is strange indeed—and the omission of such misleading commentaries as "Penguins are inhabitants of antarctic regions. Birds only in name, they have lost their ability to fly. They are very social and intelligent animals." The bibliography is barely a lick and a promise, and the addition of half a dozen or so titles would have enhanced the value of the whole book, for many do not have access to a library catalogue and are unable to follow the author's casual advice to consult one.

J. W. HEDGPETH

ROCKPORT, TEXAS

The Lost Woods. Edwin Way Teale. 326 pp. (with over 200 photographs). 1945. $4.00. Dodd, Mead & Co., New York.

EDWIN WAY TEALE'S fine photographs are familiar to all readers of the natural history magazines, and his writing is commanding a growing circle of readers. This book, essentially an expanded notebook of field trips and of observations in his own backyard, is something of a miscellaneous gathering, with abrupt transitions from Indiana to Long Island beach and Florida to Walden Pond. Such casual treatment, when reinforced by personal observations and impressions, has a charm of its own, although it can be easily overdone. Mr. Teale, however, keeps his prose within bounds, avoiding purple passages, and manages to convey to the reader something of the

fresh wonder of his own observations. He realizes, as some writers do not, that no matter how well known something may be to the professionals, it is new to everyone who sees it for himself for the first time. This attitude is essential for all popularization of science and natural history, but unfortunately it seems rarest among professional biologists in this country. However, such enthusiastic amateurs as Mr. Teale are doing very well indeed.

J. W. HEDGPETH

ROCKPORT, TEXAS

ENCYCLOPEDIA MALESIANA

Science and Scientists in the Netherlands Indies. Pieter Honig and Frans Verdoorn, editors. 491 pp. Illus. 1945. $4.00. Board for the Netherlands Indies, Surinam and Curaçao, New York.

"I DO not understand how any one can be content until he has experienced the wonder of the tropics." That was the impression of David Fairchild upon first reaching Padang in 1895. And many have been the traveling scientists who have felt likewise. Quite naturally the tropics fall into two broad divisions: the Neotropics and the Old World tropics. A large and important fraction of the Old World tropics is the East Indies. Like the West Indies, the East Indies have been perhaps more unified in the realm of the Three Kingdoms than in the rule of their governing Kings! But from the galleon days of spice trading, the East Indies have been thought of, predominantly, as the "Dutch East Indies"—those "garden islands of the Great East"—and now we have a 491-page manual to answer queries, mark off the frontiers of knowledge, and tingle travel nerves.

This encyclopedia for the reference shelf is organized in a way that will beguile you into wider reading when you seek some particular reference, that is, if you permit yourself the inefficiency of browsing. Seventy-five authors have contributed to the manual, which consists of (1) original articles prepared expressly for the volume; (2) reprinted articles dealing with the development and status of various branches of science in the Netherlands Indies; (3) travel accounts and sketches or impressions, both early and recent; (4) *serta malesiana:* short articles, biographies, reviews, bibliographies, and commentaries; and (5) a directory of scientific institutions, societies, and workers in the Netherlands Indies at the time of the Japanese invasion. The reprinted and original contents are in the proportion of almost exactly 2:1. Yet the reprinted articles are commonly ones which up to now have not been generally accessible, having appeared in regional periodicals or in the Dutch language. The reprinted articles and translations have, furthermore, often been critically edited. Some doubt may be expressed as to the value of reprinting seventy-two pages of Wallace's *Malay Archipelago.* Much of that section is printed in small type, conducive to eyestrain if read very continuously, and the general availability of the book renders it unnecessary for the ordinary user to consult this partial reprint. On the other hand, not to have reprinted Mayr's provocative contribution on "Wallace's Line in the Light of Recent Zoögeographic Studies" would have been a genuine loss! Yet Mayr's original article is quite as accessible as Wallace's book, if not more so. It is, then, rather the greater ready reference value of Mayr's paper that makes the difference.

Among the original articles and their authors, the archeologist will want to read: Prehistoric Research (von Heine-Geldern); *Pithecanthropus* Studies (Weidenreich). For the agriculturalist there are: Veterinary Science and Practice (Frickers, Haasjes and Hoskins); Horizons in Agriculture (Honig); Rubber Program (Coombs); Rubber Culti-

vation (Tengwell); and the Hot Springs Conference (Riemens). For the geologist: Stratigraphy of Java Sea Sediments (Myers); Structural, Stratigraphic, and Economic Geology (Stauffer); Contribution of Meinesz (Field); and Volcanology (Braake). For the physical scientist: Astronomy Research (Kuiper). For the naturalist: Biota of Tjibodas (Went); Conservation of Wild Life (Westermann); and Fish and Fisheries Research (Herre). For the physician: Survey of Diseases and Clinical Medicine (Snapper).

Among the reprinted articles, useful for ready reference, may be mentioned those on: Climate and soils, climate and meteorology, soils against population density studies, livestock and veterinary science, history of quinine culture, development of Sumatran naval stores and pulpwood, hydrodynamics, history of Buitenzorg Botanic Gardens and of the Zoological Museum, paleobotanical research, Rumphius, vegetation of Sumatra, Flora and Botanic Garden of Tjibodas, Massart's Java Studies, extracts from Fairchild's writings, missionary medicine, beriberi, rabies research, medical education, Wallace's Celebes explorations, Forbes's observations in the Bantam and Preanger Regencies, phytochemical research, tobacco studies, Sumatran forest regions, mineral resources, and earthquakes!

Though the polyglot character of the contributions (most of them are in English) would make the preparation of an index difficult, yet its absence is conspicuous, especially since the contents are arranged alphabetically by author, not by subject. Thus information upon Teysmann appears on page 185—there spelled "Teijsmann"—pages 232, 302, 392, 409, and 414, but to find these references one must search through many likely articles. The reader concerned with the East Indies will browse widely and often through the whole book, for, lacking an index, in no other way can its resources be mastered. Sumptuous in its format, printed on heavy plate paper of good quality, free from printer's errors, and well bound, the book is of enduring beauty. The 134 text figures and full-page plates (with fully documented sources) are well selected. Krakatao from the air is exciting. Many reproductions make the names of Nieuhof, Blume, Rumphius, and Valentijn come alive. Along with the maps and photographs, these reproductions enliven a book that under less imaginative editorship might have appeared as musty as an old Amsterdam garret. From the Bird of Paradise cover medallion to the rear end-papers, this encyclopedia *malesiana* is a satisfying, authoritative manual of importance. N.B.: Not the smallest satisfaction comes from the book's modest price—about four-fifths of a cent per page!

In the spirit of "one world" the editors write: "We hope there may be, among the readers of this volume, some who will feel drawn toward the Malaysian Islands, some who will feel that they have a training and knowledge which can be used there for the good of mankind. We also trust, and confidently, that the spirit of humanism and honest internationalism, unhampered by prejudices of race, creed, or personality, will guide the future of science and its applications in the Netherlands Indies."

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GLAMOURIZING SNAKES

They Hop and Crawl. Percy A. Morris. 196 pp. Illus. 1945. $3.50. Jaques Cattell Press, Lancaster, Pa.

THERE has long been a need for a single volume which would adequately treat the reptiles and amphibians of the northeastern states in a way comprehensible to the layman or the beginning

student. This book might have been such a volume, but it is not. It claims to deal with the continental United States, which it does not do at all adequately (not a single Pacific Coast species is mentioned), and while there is "special emphasis" on the forms east of the Mississippi, I note the omission of two families and at least fifteen genera of this area. Among the forms not mentioned are: two salamander species which are common in New York and in Pennsylvania; the very extraordinary amphibian Siren; the most common sea turtle on the northeastern coast; and the only Amphisbaenid lizard in the country. At this rate of omission it seems strange that space is given to a considerable number of forms of the southwestern desert area. New England is the area most adequately covered, only one species being omitted.

The statements about the animals themselves leave much to be desired if they are meant to be used in identification. There are no keys for this purpose, and less than half the species are figured. Many of the statements about range, habitat, habits, food, etc., are erroneous, and such errors occur even in the accounts of northeastern forms.

In a work of this kind I can see no reason why the species of a genus or the genera of a family should not be grouped together, but this normal arrangement is frequently not adhered to. Classification is a part of the science, and it is just as easy and just as "human" to treat the species of a genus one after the other, as it is to intersperse them with species of other genera, and thus abandon (not "humanize") the scientific arrangement.

The author seems to have relied entirely on books already written for laymen. Indeed, to a considerable extent he seems to have been "humanizing" the writings of Ditmars, and of books of the "Handbook" type, and it would seem that he has not consulted some of the best or most recent of these. Aside from a quotation or two from Holbrook (over a century old) there is no evidence that he has consulted any scientific work in the field of herpetology; even the local guides to special groups such as Babcock's *Turtles of New England*, Bishop's *Salamanders of New York*, or Surface's *Serpents of Pennsylvania*.

Reading this book may well help to dispel prejudice against reptiles and amphibians and "humanize" these animals. As an attempt to humanize herpetology, or as a guide to a beginning student, it is quite unsatisfactory. It would not be advisable to *use* the book except in New England.

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SOIL CONSERVATION OR WORLD FAMINE

Food or Famine: The Challenge of Erosion. Ward Shepard. x, 225 pp. Index. 1945. $3.00. The Macmillan Company, New York.

Pay Dirt—Farming and Gardening with Composts. J. I. Rodale. x, 240 pp. Bibliography. 1945. $3.00. The Devir-Adair Company, New York.

FOOD or famine; conservation or waste; pay dirt or impoverished soil; to plow or not to plow; to be or not to be; peace or war. This is a day of drastic alternatives that stem from land and how it is used. Ward Shepard in *Food or Famine* sounds the alarm of danger in wastage of soil through erosion. Our food supply is imperiled by depletion and impoverishment of soil that supplies food and fiber, fuel and timber, and other raw materials for a host of things brought forth by modern technology. To undermine the productive capacity of the land is a calamity now and will become more so as demands of increasing populations grow. The world is faced with famine, for land has been misused nearly everywhere. Only in a few localities is the land used in such

a way as to assure sustained production from generation to generation.

Fortunately, there is yet time and still hope in recent movements for conservation of basic resources. The forest conservation movement got under way in the United States a generation ago, and now the movement for soil conservation through erosion control is under way. Only a beginning has been made, but it is a beginning built on a sound foundation, both in its technical and in its social features. Soil and water conservation measures are the outcome of tested farmer practice as well as of scientific experiments. They are technically sound.

Moreover, the mechanism by which the farmer, community, state, and nation collaborate in safeguarding the basic national heritage in the soil is founded on democratic principles; it safeguards and fosters a great national resource of individual initiative of the people; and it sets the initiative going within national objectves for the general welfare. This mechanism is the Soil Conservation District, which by state enabling legislation becomes a legal subdivision of the state. Its five elected district supervisors are empowered to call on any agency, state or federal, to assist the district in conservation of soil and waters, grass, and woodlands or forests, and in making full use of each resource.

Shepard believes this movement is one of the most significant in the country today by which the findings of science may be put to practical use for the benefit not only of farmers—the custodians of the land—but of the nation as a whole.

How far do the appalling effects of soil erosion, forest devastation, and river pollution call for the exercise of public controls? What will the people say? What will the courts say? Is full conservation possible by private enterprise? What should be done in cases of large-scale land abandonment and tax delinquency? How may land reconstruction or restoration be financed? What is the value of land apart from its selling price? How may public policies in conservation be implemented? These and other questions are discussed against the background of American experience with public works, land acquisition, and the Civilian Conservation Corps.

Land controls the rivers. Integral development of watersheds on the pattern of the Tennessee Valley Authority has many advantages in achieving full use, with conservation of interrelated resources. Objections are examined, but democratic participation can meet these objections and achieve the basically important aims in conservation and sustained use of land, waters, and forests.

And what about conservation and use of resources of the world?

As if in answer to some of the questions raised by Shepard in *Food or Famine*, J. I. Rodale in *Pay Dirt—Farming and Gardening with Composts* hails a revolution in farming. Depleted soils may be restored and improved in their production through composting. Special emphasis is laid on keeping up biological processes of preparing plant foods for crops. Dangers of resorting too readily to chemical farming as against biological farming are stressed. Chemical fertilizers, while furnishing chemical foods for plants, retard or destroy certain biological conditions that are essential to the most satisfactory plant and crop growth. The commercial farming now in vogue built on chemistry without due allowance for soil biological processes and controls is being challenged by practical farmers, soil biologists, agriculturists, nutritional authorities, physicians, and conservationists. Food that must be supplemented by vitamin pills is an indictment of "modern" agriculture.

The author asserts that plants that

get their nutrients through organisms, bacteria, and mycorrhiza rather than through chemical solutions of artificial fertilizers are less susceptible to attacks of diseases and insects. Moreover, such plants are purported to impart to livestock greater immunity to disease. It is alleged that human beings nourished by plants grown on biological nutrients and by animals feeding on such plants are also more immune to disease. This relationship has been claimed before by Russell M. Wilder, but the evidence for so weighty a deduction is not sufficient nor adequately marshalled in this book. While presumption for this conclusion is strong, there is need of further investigation to discover how far and under what circumstances immunity to disease can be traced back to biological and chemical relations of plants to soil.

Much is made of the role of earthworms in preserving fertility of soils. Earthworms feed on humus as they work, and treat soil and make it more productive of plant growth. Accumulations of insecticides in soils kill much of the bacterial life and earthworms, known to be important to maintenance of soil productivity.

Despite more hospitals, more physicians per capita, and the finest medical scientists, working in heavily endowed and elaborately equipped laboratories, draft boards rejected more than 40 percent of the nation's manpower for physical unfitness, most of which was due to malnutrition. And now malnutrition may be traced back to deficiencies in the soil. China, by returning human and animal wastes to the fields, has supported dense populations on the same land for many centuries. But in America the discharge of such wastes into rivers, and thence into the sea, impoverishes soils of mineral elements and perhaps of complicated oganic compounds significant for plant growth.

Is our health related to the soil? is a question raised but not completely answered. This question, however, needs a thoroughgoing answer. It is vital to national and to human welfare the world round—perhaps more than we know to peace of the world.

Pay Dirt is a challenging book; it would be more convincing if experimental results were the foundation of the author's conclusions rather than citations of a wide range of authorities from many parts of the world. This generalized treatment of vital subjects will arouse interest. But there is also badly needed for the general public a clear, concise, nontechnical treatment of the problems and experiments. This is a field of scientific investigation in which the essential discoveries and the results of experiments can and should be put in language that laymen will understand. Thus they will become common knowledge throughout the population.

Rodale in *Pay Dirt* leaves to others the questions of depletion and destruction of the physical body of the soil resource by soil erosion. Accelerated and induced erosion, unless controlled, removes and sorts the soil, separating its fractions by more or less great distances. Advanced gully erosion may cut up land beyond use for cultivation.

Shepard and Rodale, in these two books that largely supplement one another, enliven with prophetic implications the treatment of old and new facts. They should stimulate more discoveries of science and practice in these fields. There is no more important problem before the United States and the world of today and tomorrow than how to grow and increase crops on a limited land area for a growing world population with its augmented demands.

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SCIENCE ON THE MARCH

THE CHEMICAL TREATMENT OF SEED

ALONG with hybrid corn, mechanized cotton growing, and rustproof wheat, we can include protectant seed treatment as one of the great agricultural developments of the past decade.

Chemical seed treatment is not exactly new. In 1670 a wheat ship was wrecked off the coast of Bristol, England. Economical farmers salvaged the salt-soaked grain and, since it was unfit for bread-making, used it as seed. Shrewd observation soon revealed that the salted grain produced a crop that was singularly free from the smut disease, and for years thereafter the English wheatgrowers regularly practiced "pickling" their seed in brine. But modern research has led to great advances in both the theory and practice of seed treatment, the success of which is witnessed by wholesale adoption of seed treatment in American crop production.

There are various motives for treating seed. Seed are often contaminated with spores or bacteria of plant disease, a consequence of disease in the seed crop. A principal reason for seed treatment is to destroy these dangerous seedborne sources of disease in the subsequent crop. But even a sanitary seed is not safe when planted in ordinary soil, which contains many aggressive fungi and bacteria that can attack the sprouting seed or delicate seedling before it has become a robust, self-supporting young plant. Chemical seed treatment also has the purpose of surrounding each germinating seed with a protective chemical smoke screen through which the pathogens of the soil cannot penetrate. Seed treatments for these purposes are termed "protectant," are the subject of this discussion, and are to be distinguished from seed treatments with other ends in view.

For example, there is the treatment of leguminous seed with a suspension of the beneficial nodule-bacteria which enable these plants to fix atmospheric nitrogen and restore it to the soil. This poses a problem: if protectant seed treatments are to be used on leguminous seed, some means must be found for securing the protectant action without interfering with the bacterial inoculation.

Then there is the practice of treating some hard-coated types of seeds with corrosive chemicals to soften the seed coat, facilitate entry of water into the seed, and permit its prompt germination. This is a type of seed treatment in frequent use in the propagation of hard-seeded trees and shrubs.

An old farmers' recipe calls for treating corn and peanut seed with kerosene, turpentine, or creosote in order to repel crows and rodents and discourage them from feeding on newly planted seed. This may sometimes succeed in its purpose, but it may have the opposite effect: crows have been observed systematically working down the planted row pulling up every tiny seedling in apparent hope of finding one free from the repellent odor. In this case it would have been less injurious had the bird dined on the first seeds encountered and flown away contented.

Still another type of seed treatment that has made scientific headlines recently—and temporarily—is treatment with growth-promoting substances in the hope of increasing the vigor of growth and yields. The early, enthusiastic reports of hormone seed treatments have not been substantiated by later, more thorough, testing. Seed treatments with insecticides have also been advocated for imparting to the plant a resistance to insect attack. This type of treatment as yet has no scientific basis. Recommenda-

tions for its use include simultaneous nitrogen fertilization of the soil, which alone is probably responsible for the advantages claimed for the seed treatment.

Returning, then, to *protectant* seed treatments, we find their use rather limited until the past decade. A bichloride of mercury dip was in use for seed potatoes and a few types of vegetable seeds, formaldehyde seed treatment was recommended for preventing oat smut, and copper carbonate dusting of seed was the standard control measure for wheat smut. None of these treatments had much value in protecting seed from soilborne plant disease organisms: the mercuric chloride because it was washed off before the seed were planted; the formaldehyde because it evaporated soon after treatment; and the copper carbonate because of its poor quality as a protectant in the soil.

With the introduction of the organic mercury seed disinfectants in the early 1930's there began a new era in seed treatment. These were excellent fungicides against both seed- and soilborne pathogens, and since they were in the form of dusts, the process of treatment was much simplified over the older liquid dip methods, which required subsequent washing or drying of the seed.

For small grains there was a rapid discarding of the formaldehyde and copper-carbonate treatments and adoption of the organic mercury dust treatments. More spectacular was the wholesale adoption of mercury dust treatment for cotton, seed of which had not previously been treated. The figures on cottonseed treatment tell the story. In North Carolina the acreage planted with treated seed rose from 7,000 acres in 1935 to 600,000 in 1939, and in 1941, 87 percent of North Carolina growers used treated seed. Similar enthusiasm was reflected in adoptions across the other Cotton Belt states to Oklahoma, where, in 1942, 80 percent of the growers used treated seed as compared with only 5 percent 3 years before. Such phenomenal adoptions are not to be explained by publicity alone; they could never have occurred had not the cotton farmers themselves become convinced that cottonseed treatment is a form of low-cost insurance that pays rich dividends in the saving of seed, in better stands of seedlings, and in higher yields. In the past it had been customary to plant ten times as much cottonseed as was expected to produce mature plants and then resort to laborious hoeing to thin the irregularly scattered seedlings to an even spacing. Now many of the cotton growers use much less seed and "plant for a stand," in the reasonable expectation that the majority of treated seeds will produce healthy plants. This reduces, or in some cases eliminates, the cost of "chopping," reduces the seed cost, releases cottonseed for oil crushing, and produces stronger, higher-yielding plants.

General seed treatment for vegetables soon followed. The great pea-canning industry led the way, turning 100 percent to the use of seed treatment on the cannery farms. Hybrid corn received such a boost from the treatment that today practically all the seed corn produced in the Corn Belt is pretreated before sale. Workers in the many experiment stations initiated cooperative, uniform vegetable seed treatment tests and soon a flood of bulletins was released, with reports that nearly every kind of vegetable crop profits from protectant treatment. Sometimes the results were nothing short of phenomenal, with spinach stands, for example, increased up to 1,000 percent, and yields proportionately increased when treated seed germinated under conditions favorable for seedling attack by plant disease organisms. Further indication of the acceptance of the practice is seen in the fact that one of the largest mail-order houses now offers for sale only treated vegetable seed.

With these adoptions came marked improvements in the nature of the protectant dusts. If Farmer Jones carelessly leaves the lid of his seedbox open and his cow makes a meal of the treated seed, she no longer dies, as formerly would have been the case when the highly poisonous mercury dusts were used. The newer protectants, organic sulphur compounds, while often of equal or even superior effectiveness, are much less toxic than the mercury compounds. They are less likely to injure the seed if used in overdoses. And, best of all, both the protectant dust and the nitrogen-fixing bacteria can be applied to leguminous seed without interfering with the functioning of the latter.

The work goes on. Still newer, better, seed protectants are in the testing stage. The testing is being extended to include seed which have not previously been treated as a general practice. The effect of treatment on retention of seed viability is being determined. Methods are being developed to determine whether or not commercial seed has been treated. The friction due to dust on seeds, which may interfere with free flowing of the seed through the planter, is being reduced by changes in the composition of the seed protectants. Some states have adopted laws requiring that imported seed be treated.

The amount of seed protectant used is often very small, perhaps .5 ounce per bushel of seed. If this amount of chemical—sometimes too small to be detected by ordinary inspection of the seed—produces such notable results, it was natural to inquire whether increase in the chemical dosage would lead to further advantages. But here a difficulty arose: there is a limit to the amount of dust that will adhere to smooth-coated seeds.

Soon a way was found to by-pass this difficulty. Seed were coated with a sticky layer of quick-drying plastic, into which could be incorporated much larger quantities of seed protectant than could be carried by ordinary seed. This practice of "pelleting" seed has proven valuable in onion culture, and experiments are now under way on a broad scale to determine whether it is advantageous to other crops.

There is much indication that we are rapidly approaching the time when there will be a desirable seed protectant for every major crop, and when seed treatment will be regarded as much a routine in crop production as tillage of the soil.

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COMPRESSION DISTILLATION

ONE of the interesting and significant developments fostered by the war is the cheap production of very pure water by compression distillation. Water is one of the commonest substances, but its powerful solvent action makes it very difficult to obtain in a high state of purity. The new process, originally developed to produce battery water for submarines, not only gives a product containing less than one part per million of impurities by a single distillation, with sea water as a feed, but at a cost which may be less than 10 cents per hundred gallons.

In 1824 Carnot set forth the principles of the conversion of heat into work, and in 1849 Joule proposed the reverse process as a "heat pump." Since, however, heat, as such, was most easily obtained by the burning of fuel, the only large-scale application of the heat pump for many years was in mechanical refrigeration. Attempts to apply the principle to househeating have been made but have not proved very attractive, because the heat pump employs relatively expensive equipment and is, therefore, best adapted to applications requiring continuous operation at a constant load. Since, also, the power used to deliver a given quan-

tity of heat is proportional to the temperature rise required, the heat pump will show its greatest economy where heat needs to be delivered at a temperature only slightly higher than that of a source from which it can be obtained.

After I had pondered these principles for twenty years, there occurred in 1935 one of those fortunate conjunctions of idea and need that are commonly referred to as "invention." As a result of an investigation by Arthur D. Little, Inc., of problems facing the U. S. Navy, it was found that the Navy needed a better means of obtaining drinking water from sea water, especially on Diesel-driven vessels, without boilers, and for landing operations on desolate islands. I recognized that here were ideal conditions for the application of a heat pump. The theoretical temperature difference above the normal boiling point of fresh water required for distillation of sea water is only about 1° F., and the heat quantities required are enormous. The first crude model built in the Little laboratories produced 4 gallons per hour with a ¾-horsepower motor, or an expenditure of only 80 B.T.U. of energy per pound of distillate, as against 300 for good quadruple-effect evaporator plants. Comdr. J. O. Huse was sent to inspect the plant and at once visualized its possibilities for submarines. After nearly two years of negotiations, an experimental unit was delivered to the U. S. Naval Engineering Experiment Station at Annapolis, followed by a shipboard unit a year later, and in March 1941 production models began to roll off the assembly lines of E. B. Badger & Sons Co.

Normal operation of a compression still is preceded by heating to bring the apparatus to operating temperature and fill the evaporation compartment with steam. In regular operation, sea-water feed enters through a triple-passage heat exchanger in which it extracts heat from the outgoing distillate and the brine carrying away waste salts. The feed enters the evaporator at about 207° F. and mixes with a relatively large volume of brine circulating naturally. From the evaporator, steam is led through an entrainment separator to the compressor, which raises its pressure to about 3 pounds per square inch gauge. At this pressure, the steam condenses at about 222° F. Since the brine boils at 213° F., there is a 9° temperature differential to permit transfer of the latent heat from the condensing steam to the boiling brine. No separate condenser or cooling water is needed. In some of the more recent models, more than 175 pounds of distillate have been produced for each pound of fuel used.

The first units went into the new submarines being built in 1941, but by December of that year a considerable number of units for older submarines were in the Pacific area and several were damaged on the wharves at Pearl Harbor.

Meanwhile, mobile, gasoline-engine-driven units were developed for the Marine Corps and for the Army. These units became familiar and welcome sights to those who took part in the invasions of the Pacific islands and of North Africa.

Although originally developed primarily as a means of saving precious fuel in distant places and on shipboard, this process, like most fundamentally sound processes, proved to have many other characteristics which may be of even greater interest than its economy of power. Thus the units developed by Arthur D. Little, Inc., and E. B. Badger & Sons Co. are simple to operate, requiring control of only two valves, one for starting and one for control of the rate of feed of raw water. Any Navy engine-room rating can learn the operation in ten minutes. Another rather unexpected result is the extreme purity of the product, which, when made direct from sea water, has less than one-tenth

of the impurities allowable under Navy standards for double-distilled battery water. It is also sterile, since all the vapor is heated by compression to over 240° F.

The industrial possibilities of extremely pure water at low cost are enormous. In the photographic field alone there is a great opportunity for better and cheaper products. Pharmaceutical and other chemical industries, high-pressure steam plants, railroads, sugar refineries, and even textile factories, paper mills, and laundries in hard-water regions, may find distilled water within their reach.

Compression distillation is in its infancy. It has gone to war and made good. The same principles and techniques will be converted to peacetime use and will make pure water available practically anywhere on earth and for any purpose where real advantages would result from its use.

R. V. KLEINSCHMIDT
ARTHUR D. LITTLE, INC.

INDIAN PICTOGRAPHS AND PETROGLYPHS

OF THE many branches of archeology none appeals to the layman so much as "picture writing." First noticed by the early explorers of our country, who told of the strange hieroglyphics they had seen, they were extremely interesting to our first citizens and were believed to represent some unknown language. For many years attempts were made to decipher these "writings" by comparison with Chinese, Egyptian, and other scripts. No fewer than six hundred articles and books were written concerning a site in Massachusetts known as Dighton Rock. All such attempts were futile because the level of writing had not been reached by the primitive artists, but even today in some sections of the country I have found people still trying to decipher the pictures in the hope of reading the message.

No doubt most readers have seen examples of paintings (pictographs) and carvings (petroglyphs) in the western areas in the National Parks, where they are carefully preserved. They may even be encountered on a Sunday afternoon's drive in the country. The sites commonly consist of geometric designs or pictures of animal and human forms, which were pecked, carved, or painted upon the hard surface of a canyon wall, a boulder, or a cave ceiling. The paintings may be in any of a number of colors, in many cases still as bright as they were a hundred years ago. These pictures were drawn to represent hunting scenes or to celebrate certain events; some are mere sketches with no more meaning than the scribbles on the wall of a phone booth today. The sites occur in almost every state where the proper rock surface presents itself and where Indians lived or traveled. More than 10,000 sites exist in America today, and there were probably twice as many a century ago. Some of the pictures are very crude and have no artistic value, whereas several sites in the Southwest have painted designs of animals that equal in artistry any to be found in the caves of Europe. The same care should be given these

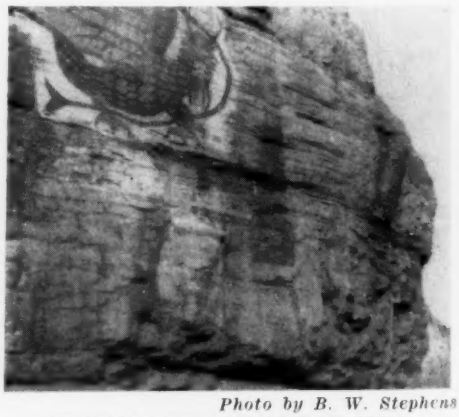


Photo by B. W. Stephens

PETROGLYPH AT ALTON, ILL.

SITUATED ON A MISSISSIPPI RIVER BLUFF, IT WAS NOTED BY LEWIS AND CLARK IN THEIR TRAVELS. UNFORTUNATELY, IT WAS DESTROYED.

Photo by National Park Service

SOME PETROGLYPHS THAT SHOULD BE PRESERVED

drawings as has been given to those in Europe.

The value of these pictures or petroglyphs is very great from a scientific standpoint. They represent the first examples of early American art in this country; their designs often give clues to religious ceremonies and tribal life not found elsewhere; finally, their very presence is often the only remaining evidence that Indians inhabited certain areas.

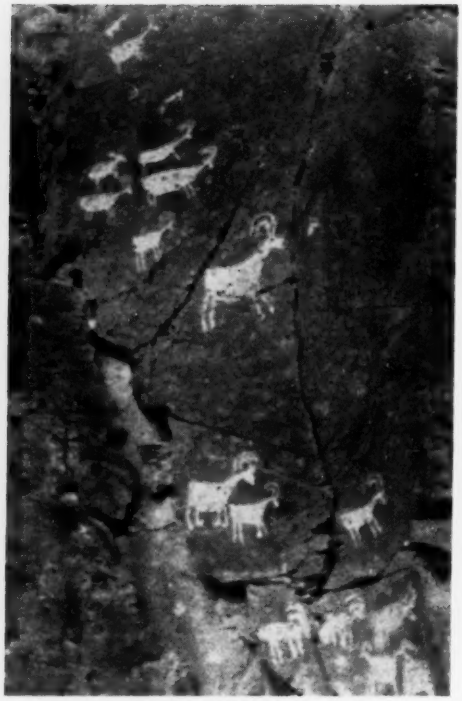
Because of the complex nature of petroglyphs and of their relation to other cultural remains, the field has been greatly neglected. Many early American archeologists merely noted the presence of unusual designs and failed to record adequately the less imposing sites. Recently, however, many papers have been published on the subject. J. H. Steward has studied many sites in far-Western states. In California he found some two hundred sites where the figures were present in great numbers. From the seeming haze of figures, circles, dots, animals, etc., Steward was able to discover differences in both design and technique in different areas. The possibility of correlating sites by a study of design elements led to a new interest in the subject. In other states workers began to rummage through old files seeking photographs and reports, and in the field a search began for new, unreported sites. Also it was noted that there were certain designs that could be called typical of various areas and that continued study of correlation would show cultural migration and infusion. Some of the workers went further and compared the petroglyph designs with those on pottery from the same area.

The possibilities of a thorough study of the subject are enormous. At present the most exact methods of dating sites depend upon use of pottery rela-

From J. H. Steward

PAINTED CAVE, SANTA BARBARA

NOTE DESECRATION OF DESIGNS BY INITIALS. THIS SITE IS NOW UNDER OFFICIAL PROTECTION.



ANIMAL PICTURES IN NEVADA

tions and tree rings. If it were possible to correlate petroglyphs with these, then for those localities lacking pottery or timber the designs would help to solve the culture problem.

The task facing the archeologist today is to locate the petroglyph sites, note the various designs, and by means of statistical methods to correlate, first, the different sites, and then the petroglyph designs with those to be found on pottery, hides, bones, etc. When this job is completed a great advance in this field will have been made.

While working on a survey of sites in the United States I have seen their rapid destruction by man and nature. In the eastern section of the country practically all the sites known fifty years ago are now gone or defaced. The loss of this material makes an accurate study of this region impossible. Most of the destruction has been due to the building of homes and roads in regions once inhabited by Indian tribes. Unfortunately, in many cases no record was made of the sites. Today those remaining are also in danger of the destruction caused by natural elements or the Sunday traveler. For example, in one case a schoolteacher took a class of children to a site, furnished them with paint, and allowed them to cover the petroglyphs with their own daubs, thus ruining a good site. In other instances vandals have carved their names over the designs or tried to blow the designs off the surface of the rock with rifles during target practice.

Scientists of all kinds—not necessarily archeologists alone—by cooperation and by means of their professional standing in their communities, can do much toward the preservation of this material so vital to the complete story of mankind's development in America. Local sites should be pointed out to the proper authorities, who will then see that the information comes to the attention of trained investigators. In this way, for generations of Americans yet unborn, their rightful heritage of a valuable historical record will be made more secure.

R. M. TATUM

ANNAPOLIS, MD.

VALEDICTION

ARTHUR MANGUN BANTA

Dr. Arthur M. Banta, Emeritus Professor of Biology in Brown University, died on January 2, 1946, at the age of sixty-eight. He had retired from active service in June 1945, planning to devote all his time to the conduct of his research.

I first met Dr. Banta in 1916 when at the end of my sophomore year I went with H. E. Walter to the summer laboratory at Cold Spring Harbor. Dr. Banta was there at the Station for Experimental Evolution of the Carnegie Institution. Our class in Field Zoology was taken to the Station to see Dr. Banta's cave. As he told us about his experiments, his friendliness and enthusiasm made a lasting impression on me that has grown with the more intimate association of recent years. A sincere and cultured gentleman, a competent scientist, he became a valued member of our faculty at Brown.

The artificial cave beneath the main laboratory at Cold Spring Harbor was the outcome of a project he started as a graduate student at the University of Indiana. He had come under the influence of C. H. Eigenmann who set him the task of studying the fauna of Mayfield's cave. His holidays were spent in making an exhaustive study of the inhabitants of this cave and of their habits. This led him to the problem of the origin of these forms with their striking adaptations to a peculiar habitat. The question of the role of the environment in the transformation of organisms confronts the investigator most insistently in the study of these adaptations. It was this question that became the focus of his research interest for life. His study was later published as *Carnegie Institution of Washington Publication #67* (1907).

He took his Ph.D. degree at Harvard in 1907 and for two years was Professor of Biology at Marietta College. When Dr. C. B. Davenport became director of the station for Experimental Evolution at Cold Spring Harbor, the work of Dr. Banta fitted so well into his program that he invited him to become a member of the staff and built for him the artificial cave under the main building. Working in this cave, Dr. Banta attempted through generations of breeding to produce inheritable adaptations in forms usually living in the light. He used crustaceans especially. He finally became convinced that within the conditions of his experiment permanent transformation of the organisms would not occur.

He was led thus to study variation and inheritance in Crustacea and selected the small, rapidly-breeding Cladocera as material. Their parthenogenetic reproduction made it possible to establish clones and thus to investigate the variation within a genetically uniform stock. In a relatively short time many generations with large numbers of individuals could be examined. *Publication #305* (1921) of the Carnegie Institution contains the results of his attempts at selection within clones on the basis of a single physiological character—reaction to light. His results he interpreted in terms of mutations.

His work with the Cladocera led him to an investigation of the role of environmental factors in the control of the reproductive processes. By control of such factors he was able to induce the production of males and of sexual reproduction in parthenogenetic lines. Many years of work on this and other related subjects were summarized in his monograph

ARTHUR MANGUN BANTA (1877–1946)

Carnegie Institution Publication #513 (1939). These books summarize and analyze the many papers that were the product of his life of research.

He came to Brown University in 1929 as visiting professor to take charge of my courses in Experimental Biology during my leave of absence. On my return he was made a permanent member of the staff and from then to his retirement taught courses in Experimental Evolution and in the Biology of Sex to enthusiastic classes of advanced students. During these years he had many graduate students who worked for the most part on problems connected with his research on the Cladocera. His students and colleagues found him always interested in them, and never too busy to discuss their problems with them.

On his retirement, he planned to continue his research on the Dauermodification—or "carry-over effects"—effects that endure over several generations after the causative factor has ceased to operate. His preliminary observations on this had been discussed in his monograph. He had obtained a grant of funds to carry on the work and was optimistically settling down in new quarters in our Biology Annex to many years of concentrated work. It is indeed unfortunate that his plans were not realized. The loss to science in such unfinished projects is irreparable, for the momentum and insight that comes with long years of familiarity and experience with the material and problems may never come again.

His death was wholly unexpected by all of us. He seemed in full vigor of health. Throughout the war he had conducted a successful and outstanding victory garden along with the rest of the faculty gardeners on the periphery of the college baseball field. We were looking forward with pleasure to having his kindly influence in our academic family for years to come. With deep regret we record his passing.

J. Walter Wilson

Brown University

COMMENTS AND CRITICISMS

On Grant's Fish Story

I have been following the explanations put forward by writers as to what caused the formation of the Carolina Bays.

The latest article, appearing in THE SCIENTIFIC MONTHLY for December 1945, by Chapman Grant, "A Biological Explanation of the Carolina Bays," in my opinion, fails to explain the formation of these flat, sandy basins, which would attract spawning fish.

To me there would seem to be a simple cause of these silted areas and I am quoting from the above article to prove my point. According to Grant on page 444: "The shallows received some surface runoff and in addition it has *numerous artesian springs* welling up through holes in the impervious layer. These springs were of various sizes, but were not necessarily large."

If there are numerous springs in this area it is reasonable to suppose that in the last great ice age they were both large and active and, because of land slippage, they would well up and change position from time to time. Hence, the depressions filled with sand that are so numerous in this area. Tidal current constant in direction would account for the shapes; drainage of the area would also help. The irregular bays are to be expected where harder strata is met with which would resist the scouring action of the springs.

Anyone who will examine areas where even the smallest spring occurs in a flat, porous expanse will see bays formed by these springs similar in many respects to the Carolina Bays.—KENNETH C. ALEXANDER.

I had thought that I was the only contributor to the MONTHLY who told big fish tales, but Mr. Chapman Grant has left me at the post. I know a good deal about fish behavior, particularly the breeding and nesting habits, but his explanation of the Carolina Bays is a new thing to me. I suspect that Professor Johnson, who before his death was for many years at Columbia University, has been making rapid revolutions in his grave at this explanation. There must be hundreds, if not thousands, of "bays" in the eastern part of North and South Carolina and probably in the northeastern part of Georgia. To make all those "bays," the fishes must certainly have worked overtime—Saturdays, Sundays, and nights—to do this job.

I spent ten summers at the Fisheries Laboratory at Beaufort, N. C., and seined all over the sounds round about. I know the fishes of the region pretty well, but I never found any of them behaving as Mr. Grant suggests, even back from the sounds in the fresh-water inlets. I also spent four summers at the Carnegie Institution Laboratory, Dry Tortugas, Fla., and watched fishes there in the shallow bays and inlets in the coral islands, but I have never seen anything like this explanation of Grant's nor have I found anything in the literature, although I have been a fish bibliographer for forty years.—E. W. GUDGER.

As a newly elected member of the AAAS, I was badly jolted to read in your December 1945 issue "A Biological Explanation of the Carolina Bays" by Chapman Grant. Certainly an article which shows such a scant knowledge of geological processes and such a studied disregard of biological data should not be published in THE SCIENTIFIC MONTHLY on a subject which is essentially geological. It simply excites ridicule for the publication and lowers the standing of the AAAS as a serious scientific body.

It is quite true that the origin of the Carolina Bays has not been satisfactorily explained by the theories advanced to date by Johnson, Melton, and others. However, the geologists and other scientists who have heretofore attacked the problem have given earnest scientific consideration to all the conditions which obtained at the time of the development of the "bays," and have drawn their conclusions with due regard to these conditions. Thereby, an accumulation of fact and scientific deduction has been built up which may well assist in a final solution of the problem. To this accumulation, Grant's fantastic statement adds nothing but a confusing cloud of irrational conclusions which are given an aura of authenticity by appearing in a publication which contains the word "scientific" in its title.

It is my opinion that the technical publication of a society which purports to advance the cause of science, should take every precaution to publish only those papers which a qualified group of men have selected to carry out the purposes of the society.—JOHN L. FERGUSON.

Perhaps our readers should be reminded that we rarely publish new and untested hypotheses. Major Grant's fish story seemed to us to be such a tour de force of the imagination that we could not resist it. So our knuckles have been rapped again. Our future experiments in the SM will be made in other directions.—ED.

Humanism

In a very interesting letter (SM, January 1946) on "The Social Significance of Jewish-Christian Intermarriage" George Wolff advocates the merging of the Jews with the peoples with whom they live by means of biologic union, accompanied by a "spiritual fusion" to be brought about by an "actual reconciliation and reunion of the Old and New Faith."

While the intermarriage part of the program is perfectly clear and one which appeals as an eminently rational approach to the resolving of the age-old strains of Jewish-Christian relationships, that part of the program relating to a "reconciliation and reunion" of "the Old and New Faith" seems vague and impractical. It is difficult to see how such a reconciliation can take place unless the Jews adopt, or the Christians give up, Jesus, either of which would not be a reconciliation but rather a conversion.

From a practical, as well as from a scientific viewpoint, another method of attaining the desired "spiritual fusion" would seem far preferable. As Wolff remarks, both the Jewish and Christian religions have the same basic ethical ideals; and from any objective modern standpoint it must be conceded that the moral content of religions is the only lasting contribution that they have made to man's advancement. However important the myths, fables, and folklore which make up the supernaturalist trappings of religions and which encrust their ethical ideals may have seemed in the past, they have now ceased to have any further social value—unless the furnishing of a livelihood for their professional advocates may be so termed.

Thus the discarding by both Jews and Christians of all supernatural, traditional, and folkway elements of their faiths, and the uniting of their identical moral code, recognizing it as the natural result of man's social progress, and divorcing it from fanciful ideas of a "divine" origin, would not only "spiritually fuse" Jews and Christians, but would bring the religious ideas of both squarely in line with current scientific knowledge. They would, as scientific humanists, then be able to live together harmoniously. Their respective religious myths would be relegated to the archives of history along with those of other ancient peoples, instead of being constantly reiterated by interested groups for the purpose, or at least with the result, of creating discord and ill will.

This method of approach would not only solve the so-called "Jewish problem," but also the "Protestant problem" and the "Catholic problem," with great benefit to all concerned. And if the Western world would have enough good sense to adopt this solution, perhaps it would serve as an example for the Near Eastern as well as the Oriental peoples similarly to solve the "Mohammedan problem," the "Hindu problem," the "Buddhist problem," and all the other "problems" raised by religions, by which, from time immemorial, the peoples of the world have been divided, and have been kept divided, into antagonistic groups.—HAROLD R. RAFTON.

Jest for Fun

In the public prints a few weeks ago I noted a United Press dispatch, originating from somewhere in New Jersey, that gave me serious pause and that I think may be of interest to those of your readers who are also writers of one sort or another. It read as follows: "The late Albert Payson Terhune is continuing his literary work beyond the grave, his widow said today. Already he has dictated three books to her, she said."

This came, you understand, right on the heels of the atomic bomb, and being still somewhat stunned by that disaster, I was a bit slow, I fear, in fully realizing the implications of this second calamity. Finally, however, I was impelled to address a few lines to Mr. Terhune himself and to others of the supernatural brotherhood who also may be carrying on empyreal literary activities and in whom the well-known *cacoëthes scribendi* may be threatening to break out in new and dangerous ectoplasmic rashes. My hope is that the apprehension that the following couplets convey may, through your widely read pages, reach the addressees in time to do some good:

Souls of writers dead and gone,
What Elysium have ye known . . . ?
When your friends laid you away,
Weren't you laid away to stay,
Or, in manner ghostly clever,
Are you going to write forever?
Even though we like your stuff,
Isn't one lifetime enough?
Must there be, without restriction,
All this otherworldly fiction,
Or, indeed, what might be worse,
Ultra-cemetery verse?
Shakespeare, Milton, Jonson (Ben),
Are you going to start again?
Goethe, Dickens, Eugène Sue,
Won't there be an end of *you?*
And there's this predicament—
Where shall royalties be sent?
To avoid such complications
Please seek other occupations;
Dead men tell no tales, you know . . .
Anyhow that *once* was so.
Incorporeal authors, han'ts,
Give us living guys a chance!

PAUL H. OEHSER

THE BROWNSTONE TOWER

April has been officially designated as the month during which an attempt will be made to arouse the nation to fight cancer with all its available resources of money, knowledge, and intelligence—to fight cancer with cold fury and warm cash as no disease was ever fought before. Can there be any mature person who has not seen a relative or friend struck down in his prime by cancer? To the agony of the victim is added the terrible helpless distress of the one who loves him most. The time comes when morphine must be used to ease the way to the permanent relief of death. But there is no relief for the memory of those who sat by the bedside—no relief except to fight cancer in person or by giving financial support for education and research to the American Cancer Society.

In our leading article in this issue Dr. E. V. Cowdry has explained the complexity of the cancer problem. It seems unlikely that a single specific drug or treatment will be found for the group of diseases called cancer. But, on the other hand, it seems certain that intensive cooperative research on predisposing factors, early detection of the disease, and possible treatments will disclose ways and means of arresting cancer supplemental to, or replacing, methods now in use. Let no one suppose that surgery and X-ray treatments, even when promptly applied, guarantee protection against the spread or recrudescence of cancer. Too often they offer only hope, to be followed by bitter disappointment.

The success of cooperative research on weapons, particularly the development of the atomic bomb, has caused people to believe that any complex problem can be solved by scientists if a large enough number of them are put to work on it and given millions of dollars of borrowed money. Let me point out that complex biological problems, such as cancer, are likely to be more recalcitrant than difficult physical problems because the former involve a larger number of factors, some only vaguely recognized and some that are extremely difficult to measure. Although large sums of money are necessary for cancer research, it is still more important to bring into the work the most talented investigators available and to steer promising young men toward a career in such research. As the procedures of the Civil Service Commission were not designed to discover and recruit scientific talent and as some good investigators do not thrive in Government laboratories, it would be inadvisable to depend entirely on the Government for the prosecution of cancer research. Furthermore, the spending of Government money, except in time of war, is not conducive to a sense of urgency and responsibility for results. Therefore, it is highly desirable that a large part of future cancer research be done in private institutions by means of funds privately contributed. In this way also contributors will have the satisfaction of personal participation in a war against cruel and premature death.

Although the American Cancer Society was founded in 1913, it was not until last year that any substantial sum was raised for a nationwide attack on cancer. From $4,000,000 contributed in 1945 a large amount was appropriated for research for the first time. In 1946 the Society plans to raise $12,000,000 of which 60 percent will be retained within the contributing states for cancer education and improvement of medical services to cancer patients. A part of the remaining 40 percent will finance a national program of cancer research under the supervision of a committee of the National Research Council. Thus a scientific general staff will tie together the work done in different institutions. If the campaign is successful, no capable investigator or no promising lead in research should lack effective financial support.

F. L. CAMPBELL